MARCH 1961

Journal

VOL. 53 • NO. 3

AMERICAN
WATER WORKS
ASSOCIATION

In this issue:

Hot Shot at Frenchman Flat spews fallout for solubility studies

1961 AWWA CONFERENCE
Detroit, June 4-9

Journal

AMERICAN WATER WORKS ASSOCIATION

2 PARK AVE., NEW YORK 16, N.Y. • Phone: MUrray Hill 4-6686

March 1961

Vol. 53 No. 3

Contents

Departments

Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 2 Park Ave., New York 16, N.Y. Second-class postage paid at Lancaster, Pa. Authorized Aug. 6, 1918. $8.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies—85 cents. Indexed annually in December; and regularly by *Industrial Arts Index* and *Engineering Index.* Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

AWWA Officers and Directors

President	C. F. Wertz	*Ch. Tech. Program Com.*	E. Shaw Cole
Vice-President	John W. Cramer	*Treasurer*	William J. Orchard
Past-President	Lauren W. Grayson	*Executive Secretary*	Raymond J. Faust
Ch. Standardization Com.	Louis R. Howson	*Asst. Secretary*	Eric F. Johnson
Ch. Professional & Adm. Practice Com.	Wendell R. LaDue	*Asst. Secretary*	James B. Ramsey
		Asst. Secretary	David B. Preston

Officers of the Sections

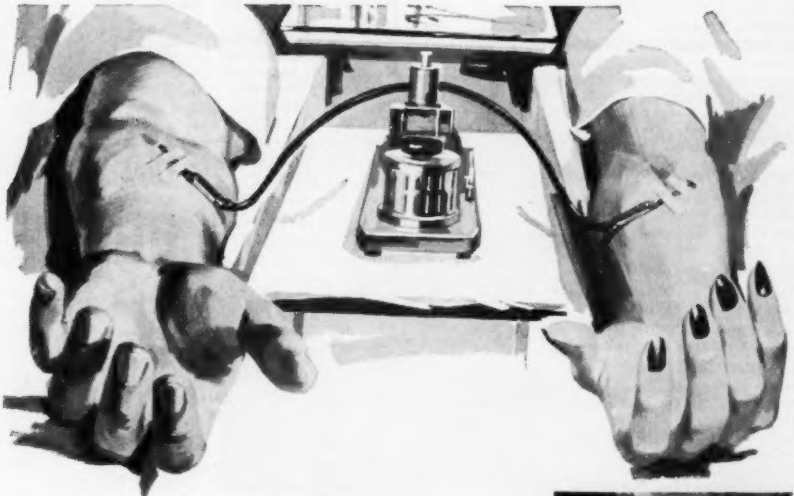
Section	*Director*	*Chairman*	*Vice-Chairman*	*Secretary-Treasurer*
Alabama-Miss.	J. L. Haley	C. M. Mathews	C. C. Williams	Ernest Bryan
Arizona	L. O. Gardner	R. E. Polenske	S. I. Roth	A. D. Cox
California	H. C. Medbery	M. K. Socha	H. J. Ongerth	F. F. Watters
Canadian	C. S. Anderson	J. D. Kline	G. E. Maxwell	A. E. Berry
Chesapeake	B. L. Werner	R. L. Orndorff	D. H. Goldsborough	C. J. Lauter
Connecticut	E. A. Bell	W. N. MacKenzie	J. E. Riordan	D. W. Loiselle
Cuban	L. Plana Astienza	R. Garcia Montes	L. de Goicochea	L. H. Daniel
Florida	J. R. Kelly	C. H. Stanton	C. A. Black	J. B. Miller
Illinois	H. R. Frye	J. C. Vaughn	K. A. Steel	D. W. Johnson
Indiana	J. L. Ford Sr.	H. A. Kerby	R. J. Becker	C. H. Canham
Intermountain	C. W. Wilson	W. C. Hague	E. J. Fjeldsted	M. W. Snell
Iowa	M. K. Tenny	H. F. Seidel	F. L. Wehrle	W. E. Bjork
Kansas	R. H. Hess	R. L. Chandler	O. R. Green	H. W. Badley
Kentucky-Tenn.	J. J. Davis	J. D. Boxley	L. H. Clouser	H. F. Mount
Michigan	H. O. Self	Tony Eikey	Gerald Remus	T. L. Vander Velde
Missouri	W. B. Schworm	F. E. Dolson	G. F. Ferrel	W. A. Kramer
Montana	Kurt Wiel	E. R. Waldo	F. B. Taylor	A. W. Clarkson
Nebraska	G. H. Beard	R. E. Arraj	G. H. Allen	J. J. Rossbach Jr.
New England	K. R. Kennison	A. J. Minkus	W. H. McGinness	R. M. Soule
New Jersey	R. E. Bonyun	P. E. Pallo	G. L. E. Linn	A. F. Pleibel
New York	J. M. Diven	C. M. Taylor	E. J. Clark	Kimball Blanchard
North Carolina	J. R. Purser Jr.	L. P. Bloxam	J. H. Henderlite	T. Z. Osborne
North Central	M. D. Lubratovich	W. J. Bell	Paul Buccowich	C. A. Flack
Ohio	M. W. Tatlock	Franklin Ruck	R. R. Deem	J. H. Bass
Pacific Northwest	W. H. Berkeley	A. H. Perry	Ray Struthers	F. D. Jones
Pennsylvania	S. S. Baxter	H. E. Beckwith	S. S. Baxter	L. S. Morgan
Rocky Mountain	J. O. Jones	Ernest Martinez	E. B. Ambler	H. F. Kepner
South Dakota	J. D. Davenport	W. P. Wells	Don Wessell	J. D. Bakken
Southeastern	C. C. Lanford	O. M. Fuller	M. E. Henley	N. M. deJarnette
Southwest	J. E. Williams	G. T. Kellogg	W. R. Hardy	L. A. Jackson
Virginia	W. B. Harman	J. B. Ferguson	J. G. Jones	E. H. Ruehl
West Virginia	D. H. Clark	Edward Shroyer	J. S. Hugart	H. W. Hetzer
Wisconsin	O. J. Muegge	E. W. Becker	J. H. Kuranz	Harry Breimeister

Directors Representing the Water and Sewage Works Manufacturers Assn.

E. E. Alt — R. V. Ford — J. A. Frank

Officers of the Divisions

Division	*Chairman*	*Vice-Chairman*	*Secretary*
Water Distribution	H. J. Graeser Jr.	J. G. Carns Jr.	A. H. Rice
Water Purification	H. E. Hudson Jr.	J. M. Sanchis	A. H. Ullrich
Water Resources	R. W. Morse	L. M. Miller	I. E. Anderson
Water Works Management	Gerald Remus	C. W. Wilson	John Copley



LIST OF ADVERTISERS

Directory of Professional Services—pp. *52-58 P&R*

Plan now for

AWWA ANNUAL CONFERENCE

Detroit, Mich. June 4–9, 1961

See page 46 P&R for preliminary program.

Coming Meetings

AWWA SECTIONS

Spring 1961

Mar. 16—New England Section, at Tufts University, Medford, Mass. Secretary, Ralph M. Soule, San. Engr., State Dept. of Public Health, Boston, Mass.

Mar. 22–24—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago 1.

Apr. 5–6—West Virginia Section, at West Virginian Hotel, Bluefield. Secretary, Hugh W. Hetzer, Design & Construction Dept., Union Carbide Chemicals Company, Box 8361, South Charleston.

Apr. 6–8—Montana Section, at Holiday Inn, Helena. Secretary, A. W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 10–11—New York Section, at Statler-Hilton Hotel, Buffalo. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 22-22 Jackson Ave., Long Island City 1.

Apr. 12–14—Kansas Section, at Baker Hotel, Hutchinson. Secretary, Harry W. Badley, Representative, Neptune Meter Co., 119 W. Cloud, Salina.

Apr. 14—California Section, at Biltmore Hotel, Santa Barbara. Secretary, Frank F. Watters, Hydr. Engr., State Public Utilities Com., State Bldg., Civic Center, San Francisco.

Apr. 19–21—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Joseph J. Rossbach, Metropolitan Utilities, 18th & Harney Sts., Omaha.

Apr. 20–22—Arizona Section, at San Marcus Hotel, Chandler. Secretary, A. D. Cox, Jr., Secy. & Comptroller, Arizona Water Co., Box 5347, Phoenix.

Apr. 23–26—Southeastern Section, at Poinsett Hotel, Greenville, S.C. Secretary, N. M. deJarnette, 96 Poplar St., N.W., Atlanta, Ga.

(*Continued on page 8*)


Modernize Your Water System
with IOWA VALVES and HYDRANTS
New industrial plants, new housing developments, population growth...all put increasing demands on today's water systems. They increase the need for effective control of water distribution...emphasize the importance of reliable, efficient and positive fire protection.
More than ever, it is important to be guided by recommendations of professional engineers, insurance underwriters and experienced waterworks operators; to have the proper spacing of shut-off valves—one at each intersection or at least every 500 feet; have a fire hydrant at every intersection—two at every intersection in business and industrial areas; have a planned maintenance program with regular inspection; weed out costly "orphans" from the system.
Experienced waterworks men are more and more choosing IOWA valves and hydrants for such modernization programs. These are products of proved design, require minimum maintenance and assure long-life, dependable performance. IOWA's long-standing reputation means continued availability of repair parts...permits choice of valves, accessories and specialties from the widest possible range.
Call in an IOWA man when your plans are taking shape.
His help can save you time and money.
IOWA VALVE COMPANY
Oskaloosa, Iowa
Subsidiary of James B. Clow & Sons, Inc.

Coming Meetings

(Continued from page 6)

Apr. 26–29—Pacific Northwest Section, at Empress Hotel, Victoria, B.C. Secretary, Fred D. Jones, W. 2108 Maxwell Ave., Spokane, Wash.

Jun. 1–3—Canadian Section, at Prince Edward Hotel, Windsor, Ont. Secretary, A. E. Berry, 72 Grenville St., Toronto, Ont.

Jun. 20–22—Pennsylvania Section, at Galen Hall Hotel, Wernersville. Secretary, L. S. Morgan, 413 First National Bldg., Greensburg.

Fall 1961

Sep. 11–13—Kentucky-Tennessee Sec., Louisville, Ky.

Sep. 13–15—New York Sec., Saranac Lake.

Sep. 13–15—North Central Sec., Minneapolis, Minn.

Sep. 20–22—South Dakota Sec., Rapid City.

Sep. 27–29—Wisconsin Sec., Milwaukee.

Oct. 1–3—Missouri Sec., Springfield.

Oct. 2–4—Rocky Mountain Sec., Taos, N.M.

Oct. 4–6—Virginia Sec., Roanoke.

Oct. 5–6—Intermountain Sec., Twin Falls, Idaho.

Oct. 8–11—Alabama-Mississippi Sec., Biloxi, Miss.

Oct. 15–18—Southwest Sec., San Antonio, Tex.

Oct. 18–20—Iowa Sec., Cedar Rapids.

Oct. 25–27—California Sec., Sacramento.

Oct. 25–27—Ohio Sec., Toledo.

Oct. 25–28—New Jersey Sec., Atlantic City.

Oct. 29–Nov. 1—Florida Sec., Orlando.

Nov. 1–3—Chesapeake Sec., Baltimore, Md.

OTHER ORGANIZATIONS

1961

Mar. 30–31—Industrial Water & Waste Conference, Rice Univ., Houston, Tex., sponsored by the Texas Water & Sewage Works Assn. Write: Professor A. W. Busch, Rice Univ., Houston.

Apr. 6–7—10th Southern Municipal and Industrial Waste Conference, Duke University, Durham, N.C. Write: Edward H. Bryan, Dept. of Civil Engineering, Duke Univ., Durham.

May 2–4—16th Annual Industrial Waste Conference, Memorial Center, Purdue Univ., Lafayette, Ind. Write: Don E. Bloodgood, Prof. of San. Eng., Purdue Univ., Lafayette.

Jun. 25–30—ASTM Annual Meeting, Atlantic City, N.J.

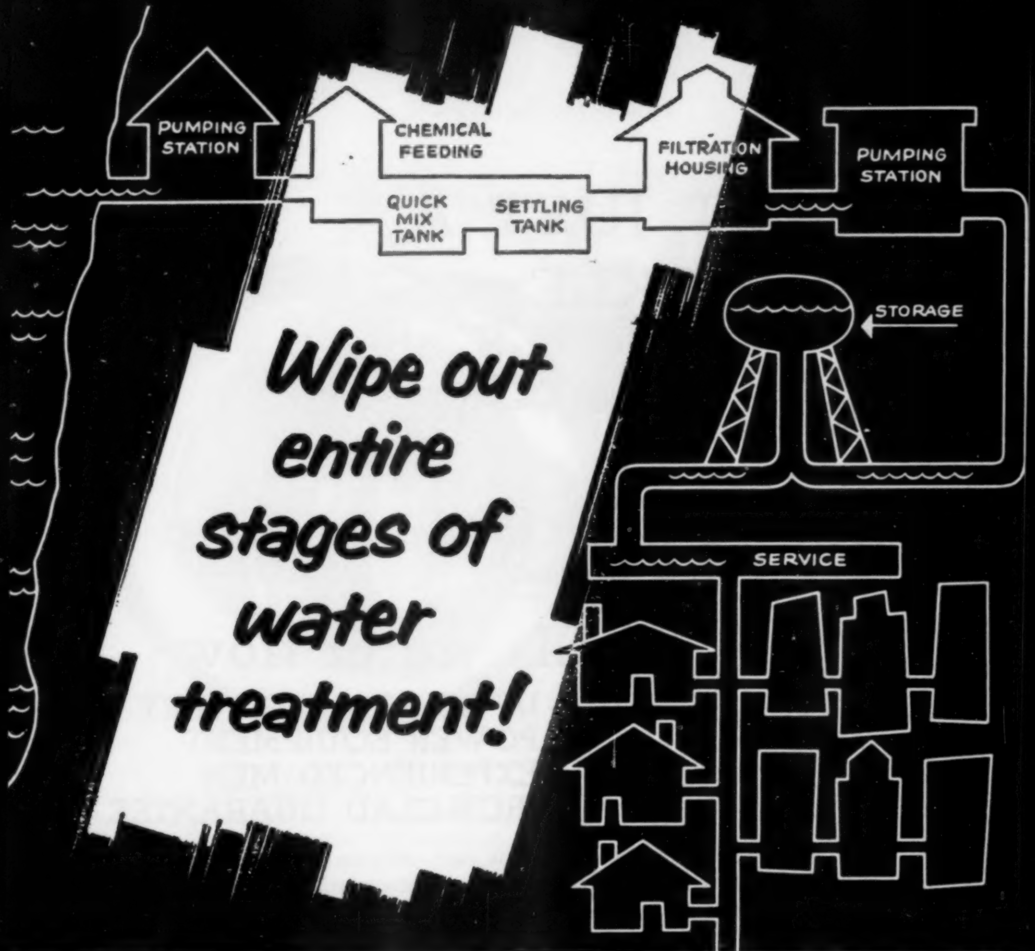
SHORT COURSES

1961

Apr. 5–7—Symposium on ground water contamination, Sheraton-Gibson Hotel, Cincinnati, Ohio. Write: Director, Robert A. Taft Sanitary Engineering Center, 4676 Columbia Pkwy., Cincinnati 26, Ohio.

Apr. 23–28—Training course on "Environmental Health Aspects of Health Mobilization," OCDM Staff College, Battle Creek, Mich., sponsored by the USPHS Div. of Health Mobilization. Write: Mrs. Jean M. Nowak, Information Officer, Div. of Health Mobilization, USPHS, Washington 25, D.C.

Jun. 6–8—5th Annual Appalachian Underground Corrosion Short Course, West Virginia University, Morgantown, W.Va. Write: John H. Alm, Rm. 605, 2 Gateway Center, Pittsburgh 22, Pa.



PUMPING STATION
CHEMICAL FEEDING
FILTRATION HOUSING
PUMPING STATION
QUICK MIX TANK
SETTLING TANK
STORAGE
SERVICE
Wipe out entire stages of water treatment!

THE MARK OF THE 100-YEAR PIPE

Adaptable

Tailor-made CONCRETE PRESSURE PIPE being installed at a southern power company.

Concrete Pressure Pipe

TAILOR-MADE TO SPECIFICATIONS

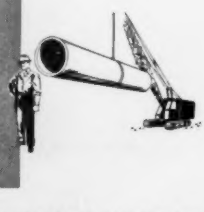
For pumping, treatment or industrial plants, concrete pressure pipe can best solve construction problems. No need to build the structure around the limited flexibility of standard fittings. Tailor-made to specific requirements, concrete pressure pipe meets the most exacting demands of entrance or exit into structures; it makes accurate connection with facilities of the building without field cutting or other makeshift expedients.

Concrete pressure pipe is also tailor-made to operating conditions, with a variety of designs to assure the most efficient pipe for specific purposes at the most economical cost.

In addition to its adaptability, concrete pressure pipe offers trouble-free service, sustained high carrying capacity and negligible maintenance requirements throughout a remarkably long and useful life.

WATER FOR GENERATIONS TO COME

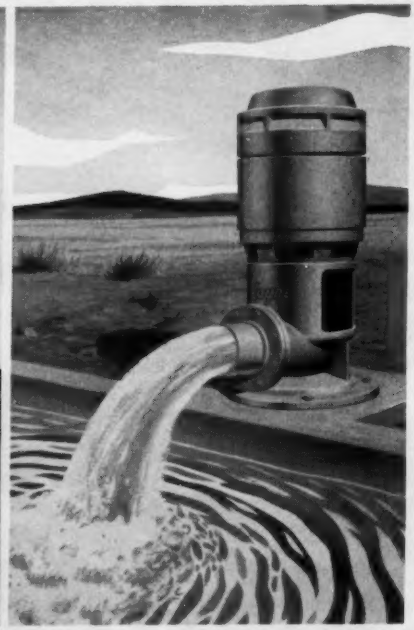
Concrete PRESSURE Pipe



AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

228 North LaSalle Street • Chicago 1, Illinois


very dependable
PATENTED SILICONE
STUFFING BOX PACKING
a name to remember
WATCH DOG
simple to maintain
Offices in principal cities
Split case or frost proof
GAMON METER DIVISION
NEWARK
NEW JERSEY
WORTHINGTON



Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 53 • MARCH 1961 • NO. 3

National Water Plan

Office of Civil and Defense Mobilization

This annex, issued in April 1960 by the Office of Civil and Defense Mobilization, supports and amplifies the National Plan for Civil Defense and Defense Mobilization, particularly Part VI, Sec. F, "Management of Resources After Attack on the Continental United States." It outlines responsibilities for providing, treating, and safeguarding water for all essential purposes during emergency, together with procedures for the emergency operation of water resources facilities.

I. Definitions

A. The term "water" is used in its commonly understood meaning. It includes potable water and all other types which are essential to the national survival.

B. The term "water supply utility" includes all public water supply systems, whether publicly or privately owned and controlled.

II. Assumptions

A. Under conditions of international tension or limited war, it is assumed * that, with the water supply systems of the nation intact, requirements for water for national defense and essential civilian needs would be met through the existing systems and any needed expansions of them. Water supply utilities, private organizations, and governments would perform their customary functions with respect to operation and expansion of water supply systems; and, in addition, the federal government would exercise its priority and allocation authority to channel needed materials and equipment for construction and operation of essential water supply facilities involved.

* See Annex 1, Planning Basis.

B. Under conditions of general war with attack upon the continental United States, a major consequence would be the shortage of water for human survival and for production of essential goods and services upon which the national survival would depend. Complete disruption of water supply service could occur in attacked cities. In many areas insufficient supplies for all purposes would result from damages to water treatment and control facilities and watershed areas. Physical damage to water supply system facilities could range from partial to complete destruction. Pumping stations would become inoperable, water mains would be damaged or destroyed, water pressures would drop greatly, and there would be little capability to provide water service in the wake of the attack. Fire caused by thermal radiation would denude watersheds and lead to subsequent erosion, reservoir or stream siltation, and downstream damage from accelerated runoff.

C. Both the quality and quantity of public water supplies would be adversely affected by the attack. This would result from contamination of water by radioactive fallout and from other damage caused by the blast and thermal effects of the attack. Covert introduction of biological and chemical warfare agents into the water supply system is also possible.

D. Immediately following attack the major water supply problem would be to meet the water requirements in habitable parts of attacked cities, in reception areas, and in communities heavily impacted by evacuees. Highest priority would be given to meeting the requirements for human consumption.

E. Postattack conditions might well require that state and local governments, industry, and families and individuals be self-sufficient for several weeks.

F. The tremendous damage and disruptions to water supply systems resulting from an attack on the continental United States probably would require substantial changes from normal peacetime responsibilities and functions.

III. General Responsibilities

A. Federal

1. The Office of Civil and Defense Mobilization (OCDM) is responsible for directing and coordinating federal activities related to water resources for most effective use of water for civil defense and defense mobilization by:

a. Coordinating the National Water Plan with other national plans.

b. Allocating interstate and intrastate water resources where a conflict in demand involves a use of prime importance to national survival.*

2. The Department of Health, Education, and Welfare (DHEW), under OCDM policy direction and program guidance, is the primary agency responsible for conducting a nationwide program to assure that there will be adequate and safe public water supplies in a civil defense emergency; for developing, with the assistance of federal, state, and local government agencies as appropriate, procedures in readiness for the allocation of water resources for essential uses in a civil defense emergency; and for performing and directing federal functions with respect to such allocation. DHEW

* See Annex 35, Emergency Administration of Essential Facilities.

shall coordinate the water supply program with state and local agencies, through existing channels between the DHEW field organization and the states.

3. Other federal agencies which have major operational responsibilities with respect to one or more aspects of emergency water supply and their broad areas of responsibility are given below.

a. Department of State: (1) American Section of the International Joint Commission of the United States and Canada—regarding joint water arrangements with Canada; (2) United States Section, International Boundary and Water Commission, United States and Mexico—regarding joint water arrangements with Mexico.

b. Department of Defense: (1) military—water for uses at military installations and the operation of surface, underground, and impoundment sources of water supply under military authority; (2) civil works—flood control, inland navigation, and operation of impoundments under direction of the Secretary of the Army and supervision of the Corps of Engineers.

c. Department of the Interior: Operation of irrigation and multiple-purpose reservoirs under the jurisdiction of the department, including those under Bureau of Reclamation authority; collection of certain basic data on water resources, including especially identification of emergency sources of supply; and emergency planning for electric power,* including hydroelectric and steam power.

d. Department of Agriculture: Guidance and assistance to farmers and others with respect to conservation and proper use of water; upstream watershed protection and flood prevention; water supply forecasts based on snowpack surveys; emergency water sources such as farm ponds and flood-retarding impoundments; revegetation of watersheds denuded by fire; and water for on-farm uses, food processing, and rural fire control.†

e. Department of Commerce: Water for industrial use and allocation of materials and equipment for repair, restoration or construction, and operation of water supply facilities.

f. Housing and Home Finance Agency: Repair, restoration, and construction of community water facilities.‡

g. Tennessee Valley Authority: Flood control, navigation, and operation of impoundments under its authority.

4. DHEW shall coordinate the development of plans and procedures under the National Water Plan with the aforementioned and other federal agencies having responsibilities with respect to:

a. Construction and operation of water facilities.

b. Claiming water for various uses.

c. Identification of available water resources and assembly of data concerning current and prospective utilization of such resources.

d. Allocation of manpower, materials, and equipment.

B. State

1. Each state, through its health agency, is responsible for supervising the health aspects of public water supplies within its borders. The health agency or other appropriate state

* See Annex 33, National Energy and Minerals Plan.

† See Annex 21, National Fire Defense Plan, and Annex 31, National Food Plan.

‡ See Annex 42, National Emergency Housing Plan.

agency is responsible for standards of quality and approval of construction plans for water supply utilities. These agencies will provide leadership and technical assistance to local water supply utilities through normal working relationships in preattack planning and training and will coordinate plans for postattack emergency operations on a statewide basis.*

2. The state agency or agencies responsible for control of state water resources will plan for the use of state-controlled waters in emergency.

C. Local

Local government is responsible for assuring adequate and safe supplies of water for essential purposes in an emergency. Under the direction of the local government, the water supply utility, whether publicly or privately owned and operated, is directly responsible for protecting and providing public water supplies in an emergency.† Water supply facilities shall be prepared to operate independently for at least one month, including reliance upon locally available stocks of water-purification chemicals and equipment. The local health and public works agencies are responsible for guidance and assistance to the water supply utility in maintaining the safety and purity of water supplies and in construction and repair of the water supply system.

D. Private Organizations

1. Industries have their own independent water systems should make provisions for emergency supplies, in order to maintain essential services and production of survival items ‡ such as food and food processing, during the immediate postattack period.

2. In preattack planning and organization, such groups as AWWA, WPCF, ASCE, and other nongovernmental organizations have a responsibility to assist official agencies.

E. Individuals

Each person or family is responsible § for providing, before attack, sufficient water for essential domestic needs for at least two weeks, since outside assistance may not be available and water service, particularly that dependent upon electric power, may be curtailed.

IV. Functions

A. Operational and Organizational Readiness

The objective of operational and organizational readiness and the responsibilities of federal, state, and local governments in this phase of the National Water Plan are set forth below.

1. *Objective*

The objective of operational and organizational readiness shall be to establish organizational arrangements and procedures within the regular operating program of each agency concerned with water supply and water

* Utility boards or other state agencies have been given this responsibility in a few states.

† Approximately 20 per cent of the water supply utilities of the United States are privately owned and operated.

‡ For listing of essential survival services and items see Annex 35, Emergency Administration of Essential Facilities, and its Appendix NP-35-1.

§ See Annex 2, Individual Action, and its Appendix NP-2-1.

resource management to provide water supplies under emergency conditions.

2. *Actions Required*

Responsibilities of the federal, state, and local governments shall be as described below.

a. Federal. Each federal agency concerned with water supply and water resource management, in accordance with its responsibilities for civil defense and defense mobilization and within regular operating programs shall:

(1) Provide assistance, through established operating channels and with the cooperation of nongovernment organizations, to state and local groups to establish plans and organizations for emergencies.

(2) Make emergency assignments to federal personnel and establish a program to provide a manpower reserve for emergency duties and to provide training for such personnel.

(3) Prepare and make available guidelines and procedures for preattack preparation, and for mobilization measures to meet various contingencies such as the circumstances incident to attack or the declaration of a limited, national, or civil defense emergency. This will include but not be limited to the following:

(a) Developing alternate sources of water supply.

(b) Guidance in methods of conserving water during an emergency period.

(c) Methods of determining the added capacities of water supply systems required during emergencies for support and reception areas.

(d) Recommended quantities of local stocks of equipment, machinery, chemicals, and fittings at water supply and control facilities.

(e) Training courses for emergency personnel in restoring and maintaining the water supply system.

(f) Guidance material for the use of suburban communities and survival groups, outlining methods and measures for developing, purifying, and using the emergency water supplies.

(g) Revegetation and restoration of fire-denuded watersheds.

(h) Restoration of reservoirs and navigation facilities.*

(4) Provide stockpiles of essential materials and equipment—such as purification chemicals, pumps, pipe, and emergency water purification units—to supplement emergency and operating inventories at local levels.

(5) Extend the damage assessment program in relation to water supplies and utilities to state and local agencies so that analyses from attack exercises can be used in planning for facilities protection, mutual aid, and emergency operation; and improve national capability to assess effects of attack on water resources and facilities.†

(6) Develop standards for facilities protection, to be made available to water supply utility and resources management.‡

(7) Conduct preattack planning at the national level so that the repair or installation of water-impounding, pumping, and treatment structures; pipelines; and other essential water production and distribution facilities and the revegetation and restoration of fire-denuded watersheds can be initiated postattack as soon as possible.

(8) Develop priorities of water use and operating procedures for federally operated impoundments so that water

* See Annex 25, Maintenance of Essential Resources.

† See Annex 14, Damage Assessment.

‡ See Annex 11, Protection of Essential Facilities.

releases may be used in an emergency to the best interest of the national defense and recovery. Both quantity and quality aspects of water required for various uses must be considered in these decisions.

(9) Conduct research and studies to develop field methods, emergency practices, and treatments against radiological, biological, and chemical agents.*

b. State. The responsibilities of the states shall be to:

(1) Establish a state emergency water supply organization and standby plan as part of the State Survival Plan within the framework of the normal operating programs of the responsible state agencies. The state plan should cover all aspects of water use, including distribution of stored waters under state control. Both quantity and quality of supply should be considered in the plans.

(2) Furnish direct assistance to local water supply utilities to set up their emergency plan and organization in accordance with state and national plans.

c. Local. The responsibilities of local governments shall be to:

(1) Coordinate local emergency water supply planning with other local emergency plans.

(2) Provide for emergency treatment and distribution of water by all available means, including vehicular transportation, and maintain liaison with the public works agency, health department, local public employment office, local civil-defense groups, and other utilities and industries for mutual assistance.

(3) Inventory alternate sources of water, treatment, and emergency distribution facilities (such as private well supplies, industrial plants, tank trucks, and swimming pool installations) and make arrangements for their use in an emergency.

(4) Maintain reserve stocks of purification chemicals, standby equipment, and spare parts so that the local water supply utility may operate on a self-sufficient basis for at least 1 month.

(5) Make agreements with adjacent systems for providing water through interconnections.

(6) Coordinate with rural agencies and community groups to plan for emergency water supplies for rural and suburban homes that are supplied by individual well systems.

B. Mutual Aid

The objective of mutual aid activities and the actions required on the part of federal, state, and local governments in this part of the National Water Plan are set forth below.

1. *Objective*

The objective of mutual-aid activities shall be to provide for exchange or assignment of personnel, machinery, and stocks of essential materials and equipment, on a current basis, among water supply utilities during emergencies.

2. *Actions Required*

Actions required on the part of federal, state, and local governments shall be as set forth below.

a. Federal. The federal responsibility in the area of mutual aid shall be to:

(1) Promote mutual-aid programs within and among states and assist in coordination of mutual-aid planning at the interstate level.

(2) Coordinate with state and local authorities to provide for satisfactory replacement of exchanged equipment

* See Annex 36, Research and Development.

or reimbursement for requisitioned material.

b. State. The state responsibility in the area of mutual aid shall be to:

(1) Promote mutual-aid programs among water supply utilities and proffer direct assistance to such utilities to organize and prepare for their participation.

(2) Coordinate the state program by actions such as: (a) maintaining master files on mutual-aid material; (b) distributing listings of such inventories of machinery and equipment to appropriate authorities; (c) conducting interstate relations.

c. Local. The local responsibility in the area of mutual aid shall be to:

(1) Make agreements with neighboring water supply utilities for mutual assistance, for exchange of basic information, and for channeling assistance when requested.

(2) Inventory machinery and equipment on a routine basis and forward such data to the master files of the state.

(3) Amend local regulations or ordinances, if necessary, so that the local water supply utility may participate in mutual-aid agreements.

C. Training

The objective of personnel training activities and the responsibilities of the federal, state, and local governments in this phase of the National Water Plan are set forth below.

1. *Objective*

The objective of personnel training shall be to improve the competence of personnel who are concerned with public water supplies in those skills required for civil defense and emergency water supply activities.*

* See Annex 37, Training and Education.

2. *Actions Required*

The responsibilities of the federal, state, and local governments shall be as described below.

a. Federal. The federal responsibility in the area of personnel training shall be to:

(1) Develop and offer technical training courses to both headquarters and field personnel and those from the state and local agencies and from industry who will, in turn, train others in civil defense and emergency water supply practices.

(2) Provide direct assistance to established state short-course programs so that civil defense may be introduced into routine course materials as a logical consideration of normal operation.

b. State. The state responsibility in the area of personnel training shall be to:

(1) Offer training to cope with disaster through established short-course programs, seminars, and special courses and demonstrations to state and local personnel.

(2) Provide direct assistance to the local water supply utilities to establish on-the-job training for their own personnel.

c. Local. The local responsibility in the area of personnel training shall be to offer on-the-job training for water supply utility personnel and reserve manpower on emergency water treatment practices and detection of chemical, biological, and radiological contaminants, and give specialized training to valving crews, emergency water-treatment crews, and others who are organized for a specific type of duty.

D. Public Information

The objective of public information activities and the responsibilities of the

federal, state, and local governments in this phase of the National Water Plan are set forth below.

1. *Objective*

As part of an organized information program,* to provide the general public with useful facts on individual action, such as simple water treatment and use of water in containers or other improvised storage facilities, that can be taken to provide safe water under postattack conditions; and with information concerning availability of emergency water supplies, the effect of nuclear attack on safety of water, and local sources of information regarding water supplies.

2. *Actions Required*

Actions required on the part of the federal, state, and local governments are set forth below.

a. Federal. The federal responsibility shall be to: (1) employ the full range of information media—especially publications, television, and radio, and direct mail—to reach the public; (2) develop information materials for use by the states.

b. State. The state responsibility shall be to: (1) promote information activities by local agencies and give assistance through guidance and provision of information materials; (2) coordinate state information activities with those of local agencies for maximum coverage and minimum duplication; (3) provide information directly where there are limited or no local information activities.

c. Local. The local responsibility shall be to provide information on water conservation, purification, and use to families through direct channels such as local clubs, newspapers, customer billing lists, and schools.

V. Execution

Emergency operating plans developed in accordance with this annex will be put into effect at all levels upon declaration of a civil-defense emergency or in event of attack.

A. OCDM

The Director, OCDM, shall establish program objectives and standards and review plans and programs undertaken by DHEW under this assignment. When appropriate, OCDM shall issue governing rules, regulations, or procedures with respect to the National Water Plan and shall adjudicate conflicting claims for water resources where a use of prime importance to national survival is involved.

* See Annex 9, Public Information.

B. DHEW

1. DHEW shall act for OCDM as the primary federal agency for coordinating the planning and administration of the National Water Plan. DHEW shall:

a. Provide for availability of emergency drinking water supplies during the immediate postattack period.

b. Coordinate and maintain necessary contacts and liaison with federal, state, and local agencies concerned with water supply and water resource management whose action is required to carry out the National Water Plan.

c. Consult with and provide technical assistance to state and local agencies and other federal agencies, as appropriate, with respect to providing

emergency community water supplies, safeguarding water quality, and determining materials and equipment requirements for water supply systems.

d. Act as claimant for necessary manpower, equipment, and supplies at national and regional levels for operation and maintenance of public water and sewerage services and facilities.*

e. Initiate and collaborate in the development of joint plans to coordinate the emergency water supply programs of other agencies having responsibilities related to water supply.

f. Develop standby plans for salvage of materials and equipment and for rehabilitation of facilities after attack.

2. DHEW regional offices shall coordinate federal contacts with state agencies having responsibility for emergency water supply activities. In emergency mobilization the DHEW regional offices shall act as arms of the OCDM regional offices.

C. Other Federal Agencies

DHEW shall coordinate the activities of other federal agencies having civil defense and defense mobilization responsibilities with respect to various aspects of water resources and water uses as outlined in Part III (General Responsibilities) of this annex. Such agencies shall advise DHEW of their plans and special problems, particularly those involving water supply activities of state and local governments.

* See Annex 18, National Health Plan, and Annex 24, National Biological and Chemical Warfare Defense Plan.

D. State

The state department of health, water authority, or other state agency delegated responsibility for emergency water supply planning will act as the primary state agency for coordination of planning and administration of the state water plan. Other state agencies concerned with water supplies or water resources will participate with the primary state agency to insure most effective use of competencies within the state organization in the area of water supply and water management.

E. Local

The management of the local water utility will direct local water supply functions. The local health department, however, will still retain primary control of general health and sanitation. Close liaison will be necessary between these groups at the local level.

F. Private Organizations

The primary groups involved will be the water works associations, sewage works associations, municipal associations, and local civic groups. Because of their channel of direct contact with individuals and local groups, these organizations can give needed assistance to official agencies in consultative capacities and in disseminating information.

Solubility of Radioactive Bomb Debris

Don C. Lindsten, Paul B. Pruett, Richard P. Schmitt, and William J. Lacy

A paper presented on Sep. 16, 1960, at the Virginia Section Meeting, Virginia Beach, Va., by Don C. Lindsten, Chief, Research Sec.; Paul B. Pruett, Project Engr.; and Richard P. Schmitt, Branch Chief, all of San. Sci. Branch, US Army Engineer Research & Development Laboratories, Fort Belvoir, Va.; and William J. Lacy, Chief Radiochemist, Physical Sciences Div., Research, Office of Civil & Defense Mobilization, Battle Creek, Mich. Pruett is now with the Office of Saline Water, Dept. of the Interior, Washington, D.C.

THE military and civilian water supply engineer is faced with the ever increasing problem of removing radioactive substances from water. The problem exists today as a result of: (1) nuclear-weapons testing, (2) operation of nuclear reactors, and (3) use of radioisotopes by hospitals and universities. The problem could exist in the future in exaggerated form as a result of nuclear war. In this event, most of the contamination would occur as a result of fallout downwind from the point of detonation. The fallout could contaminate watercourses by direct contact or could be washed in as a result of rain or other form of precipitation.

Fallout

Fallout generally consists of fission products, induced radioisotopes, and unfissioned nuclear material. These radioactive substances are trapped or fused in dirt and debris swept into the mushroom cloud of the nuclear explosion.

Various decontamination procedures have been developed to cope with the problem of contaminated water. Many procedures are very effective, approaching 100 per cent efficiency. An important consideration is the solubility of fallout in water, as this is directly associated with the efficiency of a given decontamination process. For example, the US Army Corps of Engineers has a vital interest in this question. Its newly developed "mobile water purification unit" is very efficient for removing colloidal or particulate radioactive material from water, but is relatively inefficient for removing material that is in true solution. The unit utilizes the processes of coagulation, diatomite filtration, and disinfection to treat surface raw water supplies. These processes are generally employed in municipal water plants, with sand filtration usually substituted for diatomite filtration.

A survey of the literature was made to investigate the water solubility of fallout. Most available data in the unclassified literature were summarized in hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy.[1] The percentages of the radioactive component of fallout, from various sources, that is soluble in water were given as:

1. Long-range fallout in Great Britain, 50 per cent soluble
2. Fallout particles less than 44 μ from Nevada tower shots, less than 2 per cent soluble
3. Fallout particles greater than 44 μ from Nevada tower shots, less than 1 per cent soluble
4. Fallout particles less than 44 μ from Nevada balloon shots, 14 per cent soluble
5. Fallout particles greater than 44 μ from Nevada balloon shots, 31 per cent soluble
6. Fallout particles less than 44 μ from Nevada Operation Jangle underground shots, 5 per cent soluble.

Long-range fallout, as in No. 1 above, may be as much as 50 per cent soluble in water. Close-in fallout may be very insoluble, as little as 1 per cent or less. Solubility data can be obtained only from fallout from nuclear weapons. Fission product activity from reactor fuel elements would be physically and perhaps chemically different from true fallout. To investigate the water solubility question more thoroughly, the US Army Engineer Research and Development Laboratories (ERDL), in cooperation with the Office of Civil and Defense Mobilization, conducted studies in the summer of 1957 at the Atomic Energy Commission's Nevada test site. The studies were part of "Operation Plumbbob" and were reported by ERDL.[2]

Operation Plumbbob

Participation in Operation Plumbbob at the Nevada test site was in conjunction with nuclear-shot "Priscilla." Priscilla was detonated at 6:30 AM on Jun. 24, 1957, at Frenchman Flat, Nev. The now familiar mushroom cloud is shown in Fig. 1.

Prior to shot time, fallout collection trays were installed on the Nevada desert in the anticipated direction of fallout, and as far away as 3,400 yd from ground zero. After the detonation, fallout collected from the trays was sized and sent to USPHS for study. The material used in the ERDL studies was obtained in the vicinity of ground zero. This material is more properly termed "radioactive bomb debris" to distinguish it from true fall-

Fig. 1. Nuclear-Shot "Priscilla"

The mushroom cloud over Frenchman Flat, Nev., formed 1 min after detonation.

out, which is arbitrarily defined as material deposited at much greater distances from ground zero.

All water chemistry, radiochemistry, and bomb debris solubility experiments were conducted in a mobile sanitary engineering laboratory (Fig. 2), where jar test studies were accomplished. Radioactivity counting was done in a mobile "radiac" laboratory

with a scaler * and lead shield containing a thin end-window Geiger-Muller tube. Each sample for counting was prepared by evaporating an aliquot to dryness in an aluminum planchet under an infrared lamp.

Nine solubility experiments were conducted with the radioactive bomb debris. The numbers and titles of the experiments were:

1. Effect of agitation on solubility of radioactive bomb debris in tap water
2. Effect of agitation on solubility of radioactive bomb debris in distilled water
3. Effect of pH on solubility of radioactive bomb debris in distilled water
4. Effect of concentration on solubility of radioactive bomb debris in distilled water
5. Distilled-water leaching of radioactive bomb debris
6. Acidulation and neutralization of radioactive bomb debris in distilled water
7. Solubility of radioactive bomb debris in distilled water as a function of particle size
8. Series leaching of radioactive bomb debris with distilled water
9. Pilot scale study of solubility of radioactive bomb debris in tap water.

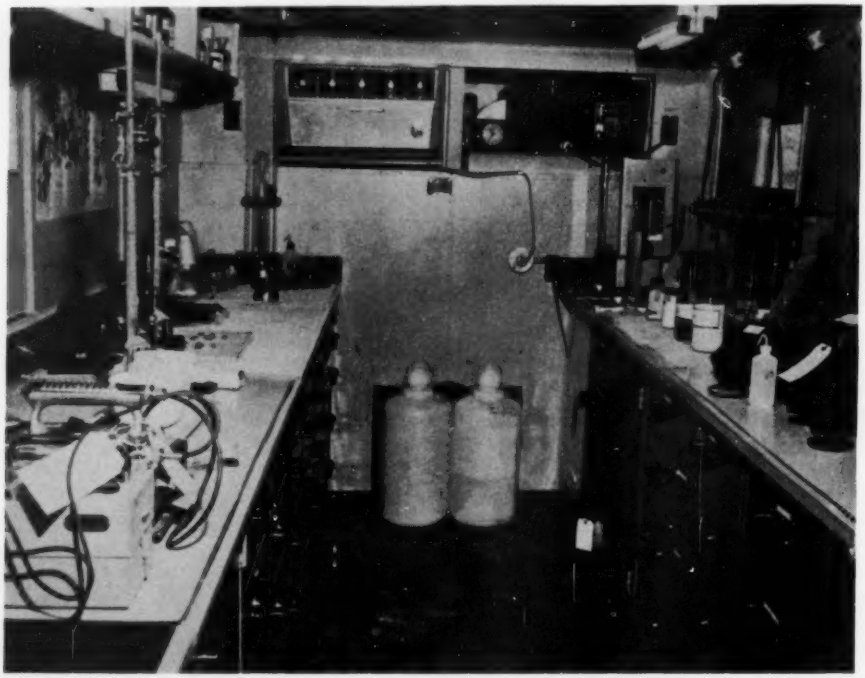


Fig. 2. Mobile Sanitary Engineering Laboratory

This laboratory was used for water solubility studies of radioactive bomb debris.

* Model 162, made by Nuclear Chicago Corp., Chicago, Ill.

Experimental Results

Experiment 1. The solubility of the active component of the radioactive bomb debris in tap water was found to vary only slightly with time of contact, at constant rate of agitation and dosage. For example, material in solution after 1 min of contact was 78 per cent of that in solution after 1 hr.

Experiment 2. The solubility and effect of the active component of the radioactive bomb debris in distilled water were similar to that in tap water (Experiment 1).

Experiment 3. The solubility of the active component of the radioactive bomb debris was found to be a function of pH, low pH giving greater solubility. For example, debris agitated in distilled water had an activity of 330,000 picocuries (pc)* per liter at pH 3.2, whereas agitation at pH 10.4 resulted in only 113,000 pc/l.

Experiment 4. Activity in solution increased with each increase in concentration of debris in contact with the water. The increase in activity, however, was not in proportion to the increase in concentration. For example, 10,000 ppm of debris produced a solution with an activity of 44,000 pc/l; 100,000 ppm of debris produced a solution with an activity of 208,000 pc/l.

Experiment 5. The solubility of the active component of the radioactive bomb debris in water by quiescent leaching was found to be essentially independent of the time of standing. Results of the first 5 days of leaching indicated no significant increase in dissolved activity. The daily increase in dissolved activity was apparently just sufficient to balance the daily loss through decay. After 5 days, an appreciable drop in dissolved activity, due primarily to radioactive decay, was noted.

Experiment 6. Hydrochloric acid was found to be slightly less effective than nitric acid in dissolving activity from the radioactive bomb debris. Precipitation of 63–68 per cent of the dissolved activity was observed as the pH of the acid solution was raised from approximately 3.0 to 10.4, which may have been the result of the formation of the insoluble hydroxides of zirconium, niobium, yttrium, and the rare earths.

Experiment 8. A sample of debris was leached with distilled water. The radioactive bomb debris in water was shown to be a function of particle size. The greatest degree of solubility was indicated when the particle size was smallest.

Experiment 8. A sample debris was leached with distilled water. The supernatant liquid was decanted and the resulting sludge releached with distilled water. The first leach had an activity of 120,000 pc/l, whereas the second leach had an activity of 49,000 pc/l. It is assumed that additional leaching would have shown even further diminution in activity present in the leach water.

Experiment 9. A total of 208 lb of radioactive bomb debris in 250 gal of tap water in a 500-gal tank was vigorously agitated for 1.5 hr. The water was then settled. Prior to slurrying, the debris was analyzed for gross count and found to have an activity of 105,000 pc/g. The supernatant had an activity of 172,000 pc/l, indicating a solubility of radioactive matter of 1.63 per cent.

Evaluation of Data

The work reported herein was devoted to a study of radioactive bomb

* One picocurie equals 10^{-12} curie.

debris from a balloon shot made at the Nevada test site during the summer of 1957. Since that time, such shots, as well as high air bursts and surface shots, have been infrequent. Nuclear testing has been restricted almost exclusively to underground testing. Even underground tests have not been held since late 1958, when the United States, United Kingdom, and Russia agreed to a 1-year moratorium on nuclear-weapons tests. Since that time, the French have announced three tests in the Sahara. At the present time, the entire weapons-testing picture is uncertain, and discussions among the three great powers are continuing at Geneva, Switzerland. In any event, data on fallout and bomb debris are difficult to obtain because of the unavailability of the material.

Limitations of data. The data collected in this project are among the very few data available concerning the solubility of radioactive bomb debris in water. It would be desirable if these data presented a complete picture of what one may expect in time of war, with all types of weapons and methods of employment, and under all conditions of weather, topography, and geography. Such is not the case. This study must be considered as only one step toward the desired understanding of water contamination to be expected in a nuclear war. On the other hand, it is essential that available information be evaluated and used to extend basic knowledge and understanding of the problem.

Ground contamination. It does not appear practical to attempt to estimate the maximum ground contamination to be expected during a nuclear war. Even a low-yield weapon detonated on, or immediately under, the surface of the ground may result in very heavy contamination in the immediate area of the target. On the other hand, atomic weapons in the kiloton range do not heavily contaminate the target area when they are detonated at heights exceeding the fire-ball radius. So-called "dirty" weapons in the megaton range are capable of heavily contaminating large areas. A significant fact is that, although the magnitude of ground contamination may vary over a wide range, the use of tactical or strategic nuclear weapons against surface targets will result in measurable contamination of the ground in the target area.

Significance of experiments. Experiments 1 and 2—devoted to a study of the effect of agitation on the solubility of debris in tap and distilled waters—indicated that, for contact times greater than 5 min, no significant increase in the dissolved components was demonstrated, either with respect to time or to either of the waters. Experiment 3, in regard to the effect of pH, indicated that pH values greater than those in normal ranges have only a limited effect on the amount of contaminant going into solution. As might be anticipated, solubility increased significantly as the pH was lowered sufficiently to remove the methyl orange alkalinity.

An increase in dissolved activity with each increase in the concentration of the contaminated soil in contact with the water was expected, as demonstrated in Experiment 4. It should be noted, however, that the increase in activity was not directly proportional to the increase in soil concentration. Data from Experiment 5—an evaluation of the effects of water leaching—indicated that water (like that in a pond) in contact with contaminated soil may reach its maximum load of contaminant in solution in a relatively short

time and that the load will not increase with time of contact. Results after 48 hr and 72 hr of leaching show that there was very little radioactivity in suspension in the supernatant. This seems to emphasize that settled water, such as that in reservoirs, will not normally contain much suspended contaminant after several days of settling, and that field survey readings of low-turbidity waters may be assumed to relate to the concentration of dissolved materials. This assumption becomes less valid when particles of colloidal size are present, or when small amounts of turbidity are kept in suspension by wave action or other factors preventing normal settling. When fallout consists of only very fine particles, a question might be raised as to whether such particles will settle at all.

Of great interest is the study of solubility of radioactive bomb debris in water, conducted on a pilot plant scale: 208 lb of material agitated in 250 gal of water (Experiment 9). The dissolved fraction was only 1.63 per cent of the total activity.

Tolerances. All water decontamination work must be evaluated in terms of existing drinking water tolerances (maximum permissible concentrations). It is important to know whether the quality of a raw water is below tolerance limits and suitable for drinking, or whether the quality is above tolerance limits and must be subjected to decontamination procedures. It is also important to know whether the finished water has, indeed, been decontaminated after being subjected to the selected decontamination procedure. As radiochemical procedures are difficult to conduct in the field, the Army drinking water tolerance limit of 300,000 pc/l is based on total concentration of activity in water, regardless of individual radioisotopes present. The tolerance limit pertains to a 1-year consumption of water under emergency conditions. The maximum value obtained during this study (Experiment 6) was 380,000 pc/l. The lifetime maximum permissible concentration given by the National Bureau of Standards [3] is 100 pc/l.

Wartime conditions. To reduce to practical terms the findings of this study and other studies, it is well to consider what can be expected on the atomic battlefield or at the site of a strategic target. It has already been noted that nuclear weapons can contaminate the soil and that the magnitude and extent of the contamination may vary widely with the size and type of weapon and the method of employment. Rain water falling on a contaminated area will become contaminated. A large portion of the radionuclides that are water soluble will go into solution relatively rapidly. This suggests that a large percentage of the soluble material will be carried off in the first rainfall, or at least in the first several heavy rainfalls. Of the total radioactive fallout reaching surface drainage systems, a fraction will be dissolved in the water; the larger fraction will be present as suspended solids. Much of the suspended contaminant will be associated with clay and other materials. Some of the contaminant may exist in colloidal form. Where effective clarification equipment and procedures are available, this suspended material should not present a significant problem. In conventional plants treating surface water, emphasis must be placed on effluent clarity. Control over chemical coagulation, filter rates, and filter backwash cycles to meet a maximum effluent turbidity standard of less than 0.5 unit would

appear to be a reasonable and attainable goal.

The presence of radioactive contaminants in surface waters will restrict the use of so-called emergency water treatment processes that rely on sedimentation alone for clarification. The new line of Erdlator-type water treatment equipment utilizing continuous coagulation and diatomite filtration is well designed to remove radioactive turbidity from water. The principal decontamination difficulty would be in removing the dissolved portion of radioactivity from contaminated water. Fortunately, the concentration of the dissolved portion appears to be quite low in relation to the total quantity that might appear in the water (less than 2 per cent in most instances during this study). Soluble ions would best be removed from water by an ion-exchange process.

Summary and Conclusions

The radioactive debris resulting from a nuclear detonation was only sparingly soluble in water. The water-soluble component dissolved quickly, with only limited additional solution taking place as a result of further agitation and contact time. Increasing the dosage of contaminated soil resulted in a higher concentration of activity in solution. Leaching the same sample a second time resulted in a solution containing less than one-half the activity in the first leach. The solubility of the radioactive debris increased as the pH of the solvent was lowered.

It is therefore concluded that radioactive debris resulting from a normal nuclear detonation is only sparingly soluble in water in the normal pH range of natural surface waters. Where effective clarification procedures are used, only the dissolved radioactive contaminants will be of importance to persons charged with the responsibility for the safety of potable-water systems. To accomplish complete decontamination, normal water-treating (clarification) processes must be supplemented by ion exchange, distillation, or another process that removes all dissolved solids from water.

Acknowledgment

Appreciation for the important role he played as project officer in charge of this study is extended to Harry N. Lowe Jr., who, at the time of this study, was chief of the Sanitary Engineering Branch of the US Army Engineer Research and Development Laboratories. He is currently deputy chief of the Missile and Space Office, US Army Engineer Research and Development Laboratories, Fort Belevoir, Va. The authors wish to thank Joseph P. Kennedy, technician at the US Army Engineer Research and Development Laboratories, for his aid in the collection of field test data.

References

1. Biologic and Environmental Effects of Nuclear War. A report presented at hearings before the Special Subcommittee on Radiation, Joint Committee on Atomic Energy, Washington, D.C. (1959).
2. Lowe, Harry N., Jr., et al. Solubility Characteristics of Radioactive Bomb Debris in Water and Evaluation of Selected Decontamination Procedures. US Army Engr. Research & Development Labs., Ft. Belvoir, Va. (1959). Available (as OTS PB152650) from Office of Tech. Services, Dept. of Commerce, Washington, D.C.
3. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure. *Nat. Bur. Standards (US), Handbook 69,* US Govt. Printing Office, Washington, D.C. (1959).

Sizing of Residential Service Lines and Meters at Detroit

Glen D. Heggie

A paper presented on Sep. 22, 1960, at the Michigan Section Meeting, Traverse City, Mich., by Glen D. Heggie, Sr. Assoc. Engr., Dept. of Water Supply, Detroit, Mich.

THE Detroit Department of Water Supply now serves approximately 700,000 residential customers representing nearly 92 per cent of the total number of services connected to the system. Nearly half of these residential services are within 49 suburban distribution systems served by the department, and negotiations are now in progress to serve at least 12 additional communities. Criteria adopted for the sizing of residential services must take into account many technical considerations and the important factor of public relations. Besides the reaction of customers within the central city, the support of officials of suburban areas is of utmost importance. This is particularly true where acceptance and application of proposed or revised standards is involved.

Increases in Service

Within recent years, utility services in residential areas have undergone significant changes. Single-family residences in the Detroit area constructed in the period immediately following World War II generally were provided with electrical service rated at 30 amp. Today, new residences must have electrical services with a minimum capacity of 100 amp. The 100-amp requirement also applies to any existing residence that is being enlarged, modernized, or having its house wiring changed. A home built just after World War II usually had four fused house circuits with provision for an electric-range circuit. Today new homes often are provided with as many as twelve fused house circuits and additional 220-volt circuits for range, hot water heater, and clothes dryer.

Gas services in Detroit have not been increased in size during the past few years, but the utility has boosted distribution main pressures and installed pressure-reducing valves at each residence. This procedure has, in effect, increased the capacity of the gas service line.

Much has been said about the increased use of electricity and gas for residential purposes, but little publicity has been given to the increased demand for water from the standpoint of increased instantaneous rate of water use. Those responsible for adequate water distribution systems and service connections are well aware of the increased usage of water because of population increase, the gradual shifting of rural population to urban and suburban areas, and the higher per capita use of water due to higher standards of living with less emphasis on economy. Further factors in the in-

creased demand for water are the development and increasing popularity of water-using appliances such as the garbage grinder, automatic clothes washer, automatic dishwasher, water-cooled central air conditioning, and underground sprinkler system, and such conveniences as home swimming pools and wading pools. Also significant is the fact that even such a seemingly unrelated factor as the increasing number of families with two or more automobiles has added to the per capita consumption of water.

Coincidental Demand

Many of the factors mentioned above contribute to an increasing coincidental demand, but there are also others. One may consider, for example, the increasing popularity of new homes featuring a bathroom for the master bedroom and at least one or more bathrooms serving the other bedrooms and lavatories for other areas of the home, such as the family room and recreation room. Although these additional bathrooms and lavatories may not materially affect the per capita water consumption, they certainly may add to the coincidental water demand of a residence.

In most communities, a coincidental demand value for residential services is arrived at by using tables included in the local plumbing code. These tables, often based on plumbing association standards, provide a means of arriving at a coincidental demand by applying a diversity factor to the sum of the demand of each fixture connected to the house piping. These commonly used diversity factors, however, may well be outmoded.

The use of automatic appliances has increased residential coincidental demand simply because the appliances are automatic. The point is that their untended operation permits the user to perform several different household chores at the same time. For example, it is entirely possible that a housewife may load the dishwasher and start it going, start the garbage grinder and leave it running, load the automatic clothes washer and start it through its cycle, and, in the meantime, draw a bath. As this is going on, other members of the family may be using one hose for washing the car or filling the wading pool, while another hose is used for lawn sprinkling. At the same time, another member of the family may be trying to take a shower in the upstairs bathroom. If the service line is inadequate, taking the shower becomes virtually impossible and the dishwasher fails to function properly, while the spray rinses of the clothes washer become weak and the cycle time of the washer is materially increased. In addition, at certain times during the deep-rinse filling period of the clothes washer, the hot-water filling valve may close because of low pressure on the hot water supply, while the cold-water valve remains open because of lesser losses in the cold water supply.

Measurements made under circumstances similar to those described above have shown that the total individual demand of the uses listed can substantially exceed 30 gpm and that the coincidental demand with the pressure drops experienced through the average service, meter, and house piping will be in the range of 15–25 gpm. If the head loss were decreased between the distribution main and the point of use, the coincidental demand could approach the total individual demand.

Head Losses

Many studies have been made of head losses in service piping, meters, and, to some extent, house piping systems. An examination of the results of these studies will not be made here. But it can be emphasized that the results of innumerable tests, including those conducted at Detroit, are in close agreement and point up quite conclusively that the major part of the head loss, or drop in pressure, occurs in the service line from the distribution main to the house meter. For instance, in 60 ft of $\frac{3}{4}$-in. copper tubing, it can be expected that 18–20 psi will be lost in the run of tubing alone at a flow of 20 gpm. The total pressure drop from the main to the house side of a $\frac{5}{8}$-in. meter in such a service line is about 26 psi, including the loss through the corporation stop, curb stop, and meter-setting gate valves. Thus, the loss in the service line exclusive of meter, valves, and fittings is about 70 per cent of the loss through a completely fitted service including a $\frac{5}{8}$-in. meter.

On first impulse, it might seem that increasing the size of the service line pipe to 1 in. would readily solve any problem of excessive pressure loss. But an examination of the head loss characteristics of typical $\frac{5}{8}$-in. domestic service water meters shows that flows in excess of 15–20 gpm will result in considerably higher head losses, and, as the author has experienced, the accuracy of the meter will be affected.

Residential-Service Requirements

Several years ago, available data on head losses in service lines were assembled at Detroit. It was concluded that a 1-in. service with $\frac{3}{4}$-in. meter should be considered for adoption as a minimum for residential services in place of the present $\frac{3}{4}$-in. service with $\frac{5}{8}$-in. meter. This conclusion was qualified, however, to the extent that such a requirement would not be needed until it could be shown that the potential coincidental demand of an individual residence approached 20 gpm. Subsequent to that conclusion, a study was made of the residential demand factor as a part of a water rate analysis. The results of this investigation revealed that the potential coincidental demand of 20 gpm for a single residence was often exceeded, particularly in newer homes located in areas that had higher than average distribution main pressures.

It is true that excessive pressure drops in residential services can be, and often are, eliminated by the householder by a self-imposed diversity factor. But does this constitute adequacy of service on the part of the water utility? Other utilities in the Detroit metropolitan area seem to be making all reasonable efforts to meet the peak coincidental demands of residential service. The question then becomes whether or not the water utility should provide the same degree of service. Any answer to this question would have to be based on local conditions including availability of water, the cost of developing additional supplies, and public opinion.

Detroit Committee

The Detroit Department of Water Supply has undertaken a study of the problem of residential-service requirements on an areawide basis, with the first step being the formation of a committee headed by a member of the department and made up of one representative from each of the three coun-

ties served by the department. In addition, the committee will include a representative from the Detroit Department of Building and Safety Engineering who will act in an advisory capacity, particularly with reference to the plumbing codes of Detroit and surrounding areas. The committee in its report will attempt to evaluate each of the many phases of the problem and make recommendations that, it is hoped, will assist the department in adopting minimum service standards. Because of the representation on the committee, it is felt that any action taken by the department will receive the support of, and will represent the desires of, the suburban areas affected by the revised standards.

The committee will also give its attention to certain related residential-service problems, such as demands imposed by nonconserving air conditioning installations, underground sprinkler systems, and large-capacity swimming pools; meter accuracy at low and high flows; the effect on the distribution system if the minimum size of residential service lines is increased; and the distinct possibility that the customer group coincidental-demand factor will increase, thus affecting the relationship of demand factors that are involved in establishing the basic water rate structure in most communities.

It is impossible at this time to predict the recommendations that will be made by the committee or the action that will be taken to implement these recommendations. One thing is certain, however. The committee will have foremost in its thoughts the prime question mentioned before—namely, "What can be considered adequacy of service?"

Conclusions

Those in the water supply industry are faced with continuing and increasingly complex problems. Principally, customer relations must be vastly improved to match those of other utilities. Adequate service meeting the needs and desires of the customer must go hand in hand with improved customer relations. Customers must be provided with the best service possible. At the same time, there must be conducted an educational campaign that will explain the increased costs that almost inevitably result from such service. Increasing the minimum size of residential services may well result in an increased cost of service, but it is believed that a fully informed public will support this action.

Sizing of Water Meters

Henry V. Aldrich

A paper presented on Oct. 18, 1960, at the Southwest Section Meeting, Galveston, Tex., by Henry V. Aldrich, Design Engr., Water Div., Houston, Tex.

THE purpose of metering a consumer's water service is essentially twofold: (1) to assure the consumer that he is receiving the amount of water for which he is being charged, and (2) to assure the supplier that he is being paid for the amount of water delivered. The meter protects the interests of both parties involved. The selection of a meter for any given service should be made with the interest of the consumer as well as that of the supplier in mind, even though it may be the supplier or his agent who specifies the type and size of meter.

AWWA standards for different types of cold-water meters [1–5] can be shown to be for the benefit of one or both parties involved in the purchase and sale of water. This is true in spite of the fact that meter standards are commonly thought of as those required of the manufacturer of meters by the water supplier who purchases them.

Considerations in Meter Selection

Having accepted the responsibility of representing both the consumer and the supplier of water in the selection of the meter best suited to the particular service involved, one must next consider what constitutes the best interests of the two parties concerned. On first thought it would seem that both parties would be equally interested in selecting the meter that, at the least cost, will pass and measure the maximum demand of the consumer without excessive wear, and will also measure significant amounts of use in smaller flows. On second thought, it occurs to one that although low cost and adequate supply are of concern to both parties, the fact that a smaller, cheaper meter may be overloaded and wear out quickly does not seriously concern the consumer, because maintenance and replacement costs are usually borne by the supplier. Furthermore, if a larger and costlier meter installed to meet the consumer's maximum demands is of a type that fails to register the smallest flows, constituting a large part of the consumer's use, one could hardly expect the consumer to protest.

For some water systems the cost of the meter is not paid for directly by the customer but is amortized by depreciation or other accounts. The problem of the person determining the correct size and type of meter for such systems is exactly the same as that of the person selecting a meter for a system that requires the customer to pay the entire cost of the meter. But the public relations job of the former per-

son is many times simpler. The public relations aspects of sizing meters, although significant, are too extensive to be discussed here.

without information about the particular requirements and conditions of water use. From this information, demand is determined, and certain

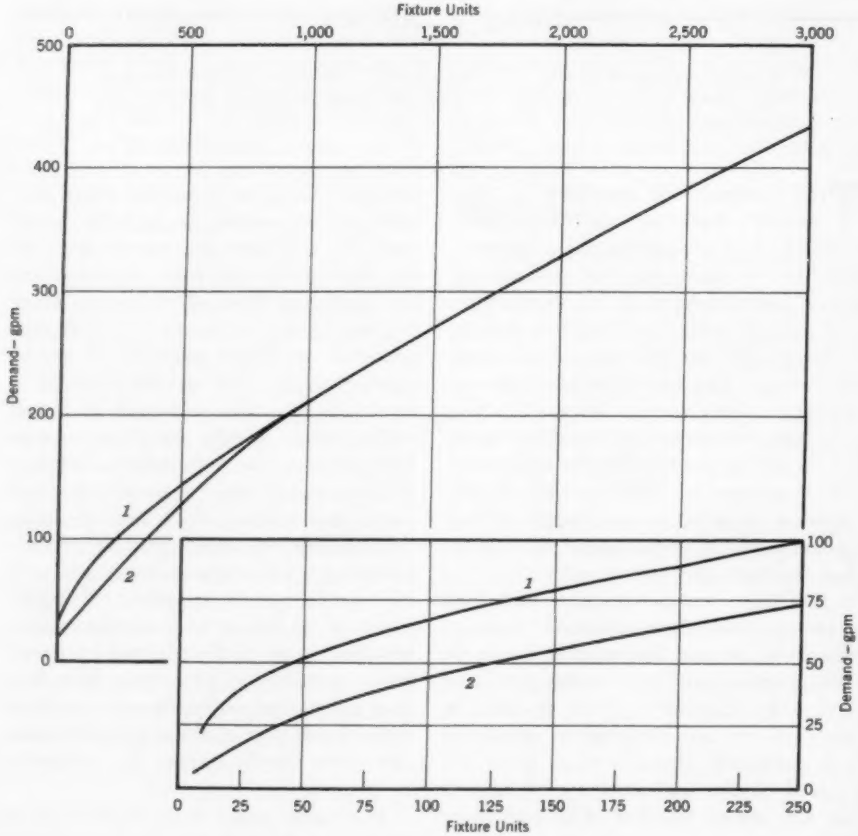


Fig. 1. Estimate Curves for Demand Load

These curves are also called "probable maximum demand curves." The inset is an enlarged scale of the demand load shown in the lower left portion of the figure. Numbers on curves represent the type of system: 1, predominantly for flush valves; and 2, predominantly for flush tanks.

Demand Determinations

The size and type of meter cannot be determined for any given service facts about the demand are ascertained. It must be determined whether it is a: (1) uniform 24-hr demand, (2) demand with regular peaks of predictable

duration and amplitude, or (3) demand that can only be predicted on the basis of the information obtained and certain methods of prediction. These are based on probability and therefore give results that are generally admitted to be only probable. In the majority of instances, however, methods of prediction give satisfactory results. In those instances where the actual demand proves to be at variance with the prediction, the information on which the prediction was made should, if possible, be examined for incompleteness or inaccuracies that can be avoided.

The first rule in determining demand is to obtain all information that may pertain to the amount of water used. Many water companies have on their application forms provision for the listing of every fixture, faucet, outlet, or appliance for which water may be required. These forms also indicate the occupancy or type of use, such as single- or multiple-unit residences, commercial or industrial buildings, warehouses, schools, or churches. Some forms assign to each water-using fixture its proper "fixture unit" value, so that the application clerk can determine the total number of fixture units in the applicant's building. Given the total fixture units for any service, one can determine the probable maximum demand in gallons per minute.

Fixture units. Table 1 lists the common plumbing fixtures for water and assigns to each its demand value in fixture units for both private and public uses. Thus, if the property to be served has no fixtures other than those listed in Table 1, it is possible to determine the sum total of fixture units. Care must be taken in totaling fixture units to separate flush-valve-controlled fixture units from the others, usually designated as "tank type." Flush-valve fixture units and tank-type fixture units cannot be added together until a conversion has been made. Figure 1 may clarify the need for this conversion.

Certain features of Fig. 1 should be noted. It can be used to determine demand in gallons per minute for a given number of fixture units. For totals of fixture units less than 1,000, and most particularly for totals of less than 500 fixture units, there is an appreciably greater demand for any given number of flush-valve fixture units than for an equal number of tank-type fixture units. This difference is the

TABLE 1

Demand Value of Fixtures in Fixture Units

Fixture*	Supply Control	Fixture Units	
		Private Use	Public Use
Bath tub†	faucet	2	4
Shower†	mixing valve	2	4
Lavatory	faucet	1	2
Toilet	tank flush	3	5
Toilet	flush valve‡	6	10‡
Urinal	flush valve‡		10‡
Laundry tray	faucet	3	3
Service sink	faucet	3	3
Kitchen sink	faucet	3	3
Dishwasher	0.5-in. outlet	1	4
Washing machine	automatic	2	
Other fixtures	0.5-in. supply	1	2
Other fixtures	0.75-in. supply	2	4
Other fixtures	1-in. supply	3	6

* Fixtures not shown in the table may be assigned fixture unit values by comparison with those fixtures listed having similar demands. For supply outlets requiring continuous operation, determine the demand in gallons per minute and add separately to the demand for fixtures.

† Tub and shower are to be considered as a single unit when combined, as separate units only when in separate stalls.

‡ Demand for flush-valve-controlled fixtures is to be determined separately from others.

reason for determining the demand for the flush-valve fixture units and for the tank-type fixture units separately and adding the two demands to arrive at the total demand. The purpose of the figure is to give a logical probable maximum demand for a number of fixtures in a system for which it is unlikely that all fixtures will be used simultaneously at their maximum capacity. For example, if one flush-valve toilet with a fixture unit value of 10 has a demand of 25 gpm, it might be thought that two, three, four, and five toilets would have fixture unit values and demands, respectively, of 20 fixture units and 50 gpm; 30 fixture units and 75 gpm; 40 fixture units and 100 gpm; and 50 fixture units and 125 gpm. Figure 1, however, shows these demands for flush-valve fixtures as: for two toilets, 20 fixture units, 36 gpm; three toilets, 30 fixture units, 42 gpm; four toilets, 40 fixture units, 48 gpm; and five toilets, 50 fixture units, 51 gpm. These values can be used to point out to a customer that, although in determining the demand every fixture is listed and accounted for, the demand is not based on a simultaneous use of all fixtures.

Procedure. A book by Oscar G. Goldman [6] has a "fixture unit conversion" chart (Fig. 2) that incorporates all the values in Fig. 1 in a form that is much easier to use and that shows more clearly the relationship between flush-valve and tank-type fixture units and their respective demands. Table 1 and Fig. 1 or Fig. 2 when used together provide a rapid and simple method for determining demand in the great majority of instances. The procedure is as follows:

1. List all fixtures that are flush-valve controlled, assign fixture unit

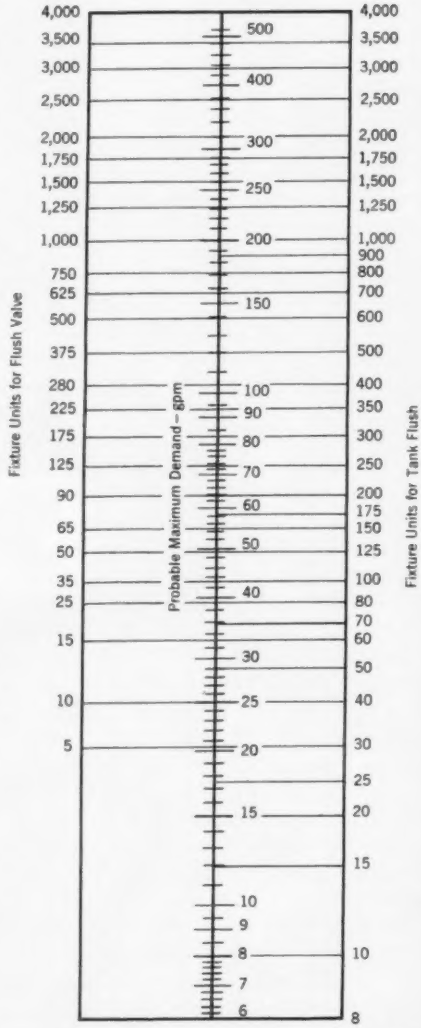


Fig. 2. Fixture Unit Conversation Chart

This chart incorporates all the values in Fig. 1. When used with Table 1, it provides a rapid and simple method for determining demand, and shows the relationship between flush-valve and tank-type fixture units.

values from Table 1, and calculate the total number of flush-valve fixture units. Determine from the portion of either Fig. 1 or Fig. 2 pertaining to flush valves the part of the probable maximum demand in gallons per minute.

2. List all other fixtures that are used intermittently, and, from Table 1 and the tank-type fixture portion of Fig. 1 or Fig. 2, determine their demand in gallons per minute.

3. List all fixtures, outlets, or appliances that use water continuously or for long periods of time during which the fixtures already listed under Steps 1 or 2 might exert their maximum demand. Determine the total demand of these continuous uses in gallons per minute.

4. Add the demands of Steps 1, 2, and 3 for the total demand in gallons per minute.

Residences, apartment projects, and housing developments are similar enough that sufficiently accurate approximations can be made by using 10 fixture units per single-family residence with one bath and 8–10 fixture units per single-bath apartment, depending on neighborhood and class of occupancy. Laundering establishments, motels, and other commercial or industrial establishments each pose their own problems. Persons responsible for determining demand should never miss a chance to secure from the washing machine or lawn sprinkler salesman, the mechanical engineer, or the plant superintendent accurate figures pertaining to the demand of his product or establishment.

Recording Devices

More data on actual use and maximum demands are needed. Devices are available which can be attached to the service meter and which will record use for 24-hr or 6-day periods. These records are of much value in determining time and amounts of maximum use during the period of record. A device that would register the highest demand, so that it could be read and recorded and the device reset each time that the meter is read, would be a practical means of determining maximum demands and detecting meters that are not properly sized. Recording demand meters might be used in this manner. But no matter how great a mass of recorded and evaluated data on demand may be accumulated, and no matter how carefully or precisely the data may be employed in the prediction of demand, there will be instances where actual use is so different from the prediction that corrections in the meter selection will have to be made.

AWWA Meter Standards

The determination of demand has been discussed at length because it is the chief factor in the selection of a proper meter. It is also the factor that, even though it is calculated by commonly accepted methods, is most subject to error owing to lack of complete information or mistaken judgment. In contrast to the general atmosphere of uncertainty and probability that so often surrounds the determination of demand is the mass of available factual data on the performance and capacities of the various water meters and their suitability for different services. Perhaps the most valuable data on meters are found in AWWA standards for cold-water meters.[1-5]

Displacement Type (AWWA C700).[1] This standard gives the safe

maximum operating capacity and the limits of flow between which displacement-type meters must register in test not less than 98.5 per cent nor more than 101.5 per cent of the flow as determined by test. It also gives permissible pressure losses for the maximum flow and states that, to avoid excessive wear, displacement-type meters should not be operated for 24-hr continuous service at flows greater than one-fifth of the safe maximum operating capacity.

Current type (AWWA C701).[2] This standard provides information on current-type meters and states that for 24-hr continuous service the meter should not be operated at flows greater than one-third of its safe maximum operating capacity. Current meters of 1.5–4-in. sizes are not recommended where flows less than certain minimums may occur. The standard specifies that, in such instances, 1.5-in. and 2-in. meters should be displacement type and that 3-in. and 4-in. meters should be compound type.

Compound type (AWWA C702).[3] The standard pertains to compound meters, which consist of a current- or displacement-type meter to measure large flows, in combination with a small displacement (bypass) meter so controlled by an automatic valve that small flows are measured by the bypass meter only. Specifications for each of the meters in combination are the same as those for the same meter alone. The changeover period is defined as the interval during which registration drops to less than, and returns to, 97 per cent as a result of valve action. It is stated that, during this interval, registration shall not drop to less than 85 per cent. The standard gives the maximum increase in flow, in gallons per minute, that will be allowed for each meter size during the changeover period. The recommended rate of flow for this type of meter in 24-hr continuous service is one-third of maximum capacity. It is further advised that, if the continuous service is to be at a fairly uniform rate, the meter size should be so selected that rate of flow during the changeover period is well below the uniform rate. The purpose of this is to avoid having a major part of the use registered at a rate of less than 97 per cent.

Fire service type (AWWA C703).[4] Meters of the fire service type are compound meters, but the main meter is a proportional type and must deliver the entire rated capacity of the meter with a maximum permissible pressure drop of 4 psi. This is in strong contrast with the compound meter, which may have a pressure drop of 20 psi when delivering its maximum rated capacity. The definition of changeover for fire service meters is the same as that for compound meters, but the maximum increase in flow in gallons per minute during the changeover period is less for the fire service type than for the compound type. In the "Notes" section of the fire service meter standard,[4] it is stated that: "The capacity of the meters given in the specifications represents the maximum rates of flow at which water should be passed through the meters for short periods of time or the peak loads which should come upon meters only at long intervals."

The AWWA standards set forth the requirements and define the limitations of the various meters. They also indicate the suitability of the various types for varied services. Displacement meters of $\frac{5}{8}$-in., $\frac{3}{4}$-in., and 1-in. sizes must deliver their capacity at no more than 15 psi head loss. Displacement meters 1.5 in. and larger, current meters, and compound meters

are permitted a 20-psi loss, but fire service meters must deliver their maximum capacity with no more than a 4-psi loss.

Other Meter Specifications

Specific data on the performance of meters of different sizes and types can best be obtained from the meter manufacturer. With the means at hand for the determination of a probable maximum demand of any service in question, and with data sheets on the various meters, the final selection of a suitable meter can be made.

Goldman [6] specified that the meter should be a size that would deliver the demand quantity with a loss of 5 psi or less. For several years at the Houston Water Division, it was the general practice to select a size of displacement or compound meter such that the probable maximum demand was 50–80 per cent of the meter's maximum capacity. Currently at Houston, the $\frac{3}{4}\times\frac{5}{8}$-in. meter is sold without sizing for service to residential buildings with not more than three dwelling units, unless the contract clerk thinks that the fixtures seem to indicate an excessive demand. Similarly, the application for a 1-in. service and meter for a multiple-residence building of three to eight dwelling units is granted by the clerk without resort to sizing. Small commercial buildings, warehouses, and real estate offices with one to three restrooms as the only facilities with a water demand are granted the small meter without question.

At Houston, the prices of services and meters in sizes from $\frac{3}{4}\times\frac{5}{8}$ in. up to and including 2 in. are fixed by ordinance and range in price from $75 for a $\frac{3}{4}$-in. service and $\frac{5}{8}$-in. meter to $290 for the 2-in. installation. These meters are normally of the displacement type, but a 2-in. compound meter may be used where the engineer or the meter shop superintendent thinks that there will be an appreciable amount of use at small flow rates. For 0.25–2-gpm flows, the $\frac{5}{8}$-in. bypass meter of the 2-in. compound meter must measure 95–97.5 per cent or more. The displacement-type 2-in. meter is required by specification to register no more than 95 per cent at a flow of 2 gpm, and may not register a flow of 0.25 gpm nor more than 65 per cent of a flow of 1 gpm.

In the Houston system, all meters 3 in. and larger are compound; this group includes the fire service types. All the compound meters have bypass connections, so that the service can be maintained while the meter is being repaired or replaced. All services with meters 3 in. or larger are installed at the applicant's expense, with advance deposits based on preliminary estimates and final settlements made on the basis of actual cost. In downtown buildings, meters set in the basement are permitted, but the greater number of the large compound meters are set in concrete vaults at the customer's property line. Costs of the compound-meter installation may be $1,000–$1,500 for a 4-in. service with a 3-in. compound meter to as much as $5,000 or $6,000 for a 10-in. meter of the fire service type. The practice of installing two or more meters of a smaller size in parallel (battery installation) to take the place of a larger meter of the correct size has never been permitted for the Houston water system.

For the simplest and most frequently occurring types of water requirements, it is desirable to establish meter sizes so that repetition of calculations is not necessary and decisions as to meter size can be made at the lowest possible level of responsibility—by the

application clerk, for example. For many of the largest installations, the architect or the mechanical engineer will specify meter size. These sizes and the method of determining them should be checked. If errors or incorrect methods are found, they should be corrected, and the correction should be explained to the architect or the engineer. Most professional men will appreciate being taught the methods used for sizing meters, and the time spent in teaching them will be well repaid when their figures can be accepted as correct with only a casual check.

Publications

The publication most frequently recommended for a number of years as an authority on water meter sizing is a joint report of the US Department of Commerce and the Housing and Home Finance Agency.[7] Goldman's book,[6] mentioned before, has been widely recommended because of its many convenient charts, detailed discussions, and illustrative examples. Also mentioned earlier are the AWWA standards for cold-water meters.[1-5] The AWWA meter manual[8] gives information in more usable form to aid in fitting the meter to the demand requirements.

Summary

Sizing a meter requires that the interests of both the customer and the supplier be equally considered. Determination of demand is predictable to a degree commensurate with the completeness of information about the service required. Selection of the correct type and size of meter for a demand of known type and magnitude can be made a matter of routine.

Many of the problems of sizing meters can be eliminated by the adoption of general rules or policies governing the use of different types of meters. At Houston, the use of displacement meters in only the small sizes and the use of compound meters in all the larger sizes have, by routine policy, reduced the number of instances when meters have been either overworked—with consequent excessive wear—or oversized—with resulting under-registration.

Acknowledgment

Figure 2, from the book by O. G. Goldman,[6] is used here with the permission of the publisher, Columbia Graphs, Columbia, Conn. Table 1 owes much of its form and content to a similar table in Goldman's book.

References

1. AWWA Standard for Cold Water Meters—Displacement Type—AWWA C700. Am. Wtr. Wks. Assn., New York (1946).
2. AWWA Standard for Cold Water Meters—Current Type—AWWA C701. Am. Wtr. Wks. Assn., New York (1947).
3. AWWA Standard for Cold Water Meters—Compound Type—AWWA C702. Am. Wtr. Wks. Assn., New York (1947).
4. AWWA Standard for Cold Water Meters—Fire Service Type—AWWA C703. Am. Wtr. Wks. Assn., New York (1949).
5. AWWA Standard for Cold Water Meters—Current Type—Propeller Driven—AWWA C704. Am. Wtr. Wks. Assn., New York (1950).
6. Goldman, O. G. *Sizing of Services, Meters, and House Pipes.* Columbia Graphs, Columbia, Conn. (1955).
7. Report of the Coordinating Committee for a National Plumbing Code. Joint Report of US Dept. of Commerce and Housing and Home Finance Agency, Supt. of Documents, Washington, D.C. (1951).
8. *Water Meters: Selection, Installation, Testing, and Maintenance.* AWWA Manual M6. Am. Wtr. Wks. Assn., New York (1959).

Water Supply Administration in Peru

Harris F. Seidel

A contribution to the Journal by Harris F. Seidel, Director, Water & Sewage Treatment, Ames, Iowa.

PERU has been characterized as three countries in one; a quick look at a map of South America will show why. The western coastal plain is a narrow sand desert of striking desolation, except where irrigation converts it to equally striking productivity. Next come three commanding, towering ranges of Andes, each higher than the one before. Approximately the eastern two-thirds of Peru is jungle—much of it unmapped, uncivilized, unreachable, and unlimited in its potential of land and rainfall.

The summit of the first range of Andes is 100 mi from Lima, the seacoast capital. A trip of several hours from Lima takes one to an elevation of nearly 16,000 ft. Moisture falling east of this first range makes its way into Amazon headwaters, then all the way across Brazil to the Atlantic Ocean.

Peru exports such staples as cotton and sugar and such minerals as copper, silver, and lead. In turn, most manufactured products must be imported, including cast-iron and steel pipe and water meters. Asbestos-cement pipe is produced in volume, and plain concrete pipe is made on the job with domestic cement almost everywhere in Peru.

With its wealth of minerals, land, and water, and the vigor of its people, the economic potential of Peru is considerable. The present installed capacity of electrical power is said to be less than one-tenth the hydroelectrical potential alone. As in the western United States, the water is not now where the people and the irrigable land are. Of approximately 50 short coastal streams, less than 10 flow all year around. Several major projects, however, are underway to bring inland water to the coastal areas.

Domestic Water Supply

Major water supplies or systems are financed and built by direct grant from the national government. Under this arrangement, it has been necessary for some communities to wait a long time for a water system.

After water is provided, another problem arises for many cities because of their very rapid growth, which, in some instances, has doubled in the last 10 years. Supply facilities and distribution systems that were adequate 10 years ago have become severely overloaded. The result may be poor pressure (or no pressure) in certain areas at certain times. This situation is then intensified by the very human customer reaction of filling containers with water to provide for such emergencies, then dumping and refilling them with fresh water the next day. The result is increased water "consumption" and still poorer service. Few water systems in Peru are in such straits, but this is an

example of the result of very rapid growth in demand where the financial support to match this growth is lacking. Few water systems in Peru are self-supporting in operating costs alone; expansion must, therefore, also be financed by grants from the national government.

Arequipa

During the summer of 1960, the author spent 5 weeks in Peru as a short-term consultant to the International Cooperation Administration (ICA), activities of which are known as the Point Four program. The consultation was a part of the Community Water Supply Development Program of ICA. Under this program, and in collaboration with the World Health Organization and the Pan American Health Organization, ICA is assisting cooperating countries to develop or strengthen business-type, self-sustaining national institutions that will plan and aid financing, construction, and management of water supply systems at the community level by the following means:

1. Provide expert consultation on planning, organization, management, and technical, legal, and fiscal matters
2. Develop human resources through education and training programs
3. Upgrade capabilities of national personnel through seminars, collection and dissemination of information on programs throughout the world, distribution of educational material and professional literature, and development of manuals and other materials
4. Make limited grants of funds to pilot projects for which basic plans have been made and limited financial assistance can help to establish effectively the desired institution or to assist in completing its plans
5. Aid countries in developing sound financial planning, essential to preparing requests for external loans as a means of creating or enlarging revolving funds
6. Encourage use of national and foreign private engineering firms and local industries to meet the country's needs.

The author's specific assignment was to serve as a consultant on rates and financing of a $7,000,000 expansion of the water and sewerage facilities of Arequipa, Peru's second largest city. Arequipa is a city rich in history and scenic attraction. It is the center of a fast-growing agricultural and trade area of southern Peru. Whether entirely justified or not, Arequipa has the interesting reputation of being the birthplace of many of the more important revolutions in Peru's history. In fact it was while striking a blow for freedom in 1930 that the citizens junked the water meters! This is one entirely valid reason why the city is still essentially unmetered today.

Arequipa is an example of a city outgrowing its water system. About 90,000 residents now have water service in their homes, supplied through aproximately 11,000 service connections. This ratio of eight people per connection, twice that in the United States, is quite typical for Latin America. An additional 40,000–50,000 people are already established in mushrooming residential areas beyond the limits of the existing water system.

Arequipa has, at present, two sources of water supply: a spring delivering 5.0 mgd and a treated river supply providing 3.4 mgd. Water consumption is at the rate of 90–100 gpcd, which seems unusually high. The explanation is simply that most

of the services are unmetered. The river supply is treated in a modern alum coagulation and rapid sand filtration plant that is a model of functional design and efficient operation. This plant is now being operated below its rated capacity. Recent developments in filtration rates higher than 2 gpm/sq ft indicate that the present plant should be able to operate at very substantial capacities above its present 3.4-mgd output.

In the $7,000,000 project are included extensive distribution system strengthening, a number of new ground storage reservoirs, extensions to serve the new suburban areas, and water meters for all existing and future services. Some improvements in supply will also be made now; additional treatment capacity will be added later as needed. Also included in the project is a complete treatment plant for a major portion of Arequipa's waste water. The effluent will be used to reclaim additional land by irrigation.

The location of the water meter, particularly in a system where a pattern has yet to be established, is an interesting challenge. Standard practice in Peru places the meter inside a shallow precast concrete box, with cast-iron lid flush with the sidewalk, just on the street side of the property line (Fig. 1). The lids are not of the locking type. Shutoff cocks are provided inside the box, and a corporation cock is provided at the main. Among the problems encountered with this arrangement are tampering with the meter, disappearance of the lids, and subsequent damage or burial of the installation by rocks, dirt, or leaves.

By contrast, electric meters are set in metal-framed boxes placed integrally in lot partition walls or front building walls at a convenient height. Placing the water meter right beside the electric meter seems to be worth consideration. It would involve running the service up to the box and back to the ground, but freezing is no problem in most of Peru. There would be less opportunity for mischief than at present, and, finally, the meter could be read at a glance, a real saving to the utility.

All engineering work, including plans and specifications for this entire project, has already been completed by the engineering staff of the national Public Works Ministry. When the work was completed, the technical help of Point Four was made available—in specialized consulting service rather than in direct engineering or financial help. In addition to aid on rates and finances extended by ICA, the Pan American Sanitary Bureau (PASB)—the Latin American arm of the World Health Organization—provided help in reviewing the feasibility of the overall project and in outlining its new organization.

Following reorganization by means of a law prepared for passage by the national legislature, the water and sewerage utility of Arequipa will be operated as an "autonomous enterprise," corresponding to the authority form of management in the United States. The new authority will be a financial entity and will have power to set rates, enforce collection, and establish service rules.

Financing and Rates

Of the total project cost, approximately half will come from local funds committed for this purpose annually for the next 10 years. The remainder will come from the Inter-American Development Bank, the newest of the international loan agencies. In any

event, the new authority will be self-supporting. It will not only meet its operating costs, but the proposed rate schedule is designed to cover debt service on both local and foreign loans and to provide a nominal reserve for depreciation and contingencies as well.

Under the proposed schedule of debt retirement, the local loan will accumulate with interest until the foreign loan is completely repaid. Repayment of the local loan funds will then begin, but not to the governmental units providing the funds; rather, repayment will go to a special revolving development fund for use by other communities.

A factor in water utility management in Latin America is the "social" rate structure that is based on ability to pay, rather than on the benefit received. This structure may involve: (1) a flat-rate schedule based on number of rooms, value of property, or similar economic index; (2) an *increasing* unit charge for increased use of water; or (3) other such provisions. The proposed rate schedule for Arequipa retains this social feature to some extent, while embodying the decreasing unit cost principle common in the United States. A sample rate schedule is shown in Table 1.

Public Works Ministry

The national Public Works Ministry has nominal technical control of, and establishes rates for, the five large water systems in Peru (at Lima, Callao, Arequipa, Trujillo, and Piura), which are locally managed. For about 70 other large and moderate-size utilities, the ministry provides direct and complete operating management. In the latter instance, all personnel are employees of the national government. Operating budgets are prepared annually in Lima; summary operating and financial data are forwarded to Lima monthly. All revenue is received by local banks (not by the utility offices) and is channeled into the national treasury. There is no separate national water utility budget. Operating costs come from national funds, and, at present, they exceed revenue by a ratio of roughly 2.5:1. But a rate increase in prospect for 1961 should balance income with operating costs, and may do slightly better. The

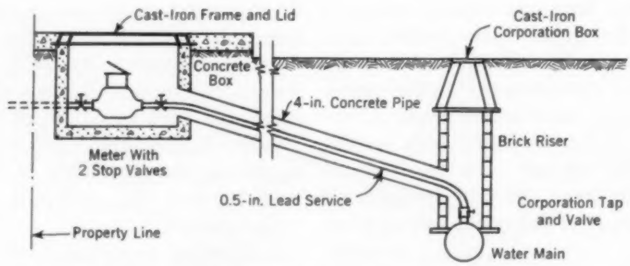


Fig. 1. Domestic Water Service Connection in Peru

Problems encountered with this arrangement include tampering with the meter, disappearance of lids, and subsequent damage or burial of the installation by rocks, dirt, or leaves.

only vital data on these 70 systems not available in Lima are individual metered-consumption records, which are available locally, and detailed plans of the distribution systems, which exist in varying degrees of completeness and accuracy. The same organization, in Lima and locally, has full operating responsibility for sewer systems.

Administration is through a sanitary engineer in the capital of most of the 24 departments, or states, of the country. He provides technical and administrative supervision of all ministry water systems in his department, although the larger ones have local superintendents who perform this function directly.

Meters

A very substantial start has been made on customer metering for these systems. Cuzco and Huancayo each have more than 2,000 services metered (more than half in each city), and several other cities have close to, or more than, 1,000 meters installed. In cities with metering programs, *all* new services must be metered, and, with few exceptions, the cost of the meter is simply included in the cost of the house connection, to be paid entirely by the customer.

The meters in use are largely of Belgian or German manufacture. The 0.5-in. turbine meters cost about $12 on direct purchase from the manufacturer abroad. Disc meters manufactured in the United States normally sell for about $17, although the Lima utility received a quotation of $15 in May 1960 from a major manufacturer in the United States. Turbine meters do not provide the accuracy or low-flow sensitivity of disc meters but are the only practical choice where the water is not perfectly clear at all times.

Sufficient data are available on water use in Cuzco, Huancayo, and several other representative cities to provide an interesting comparison with water use in Arequipa, which has been essentially unmetered prior to this time. A detailed study of water use in a residential-commercial zone of Arequipa with an adequate 24-hr supply gave an average use of 17,000 gal per connection per month. The number of people with house connections was determined to be 7.9 per service, resulting in a figure of 72 gpcd.

In contrast, meter records in the other cities mentioned indicated that only a modest number of customers in the upper brackets used more than 9,000–11,000 gal per month. Further, a large majority of those in more modest homes stayed within their minimum bill allowances of 5,000–7,000 gal per month. This is a restatement of the old lesson, still being learned in the United States as well, that meters are not only the finest billing aid but the best waste-cutting tool yet devised —far outranking ordinances, physical restrictions, or inspection.

TABLE 1

Suggested Form of Rate Schedule— Arequipa, Peru*

Domestic Category†	Minimum Bill		Allowance§	
	soles‡	*$*	*cu m*	*gal*
A	15	0.56	15	4,000
B	25	0.93	25	6,600
C	40	1.49	40	10,600
D	50	1.86	50	13,200

* A flat-rate schedule, through the minimum brackets, at 14 cents per 1,000 gal.

† All 0.5-in. services; categories pertain to size of residence and economic factors.

‡ 27 soles = $1.

§ For excess use—more than the allowance on the minimum bill—the schedule proposed is: up to 50 (or 100) cu m, 1.00 sol/cu m; next 50 (or 100) cu m, 0.60 or 0.75 sol/cu m.

Huancayo

Huancayo now has an estimated population of 85,000, double that recorded in the last census in 1948. At that time, there were 1,400 connected services and a revenue of about 4,000 soles (s/.) or $148 per month. Now there are 3,400 services and a revenue of about 50,000 s/. ($1,852) per month. New connections are being added at the rate of 30–50 per month.

Huancayo is served both by a spring supply, for which no treatment is needed, and a new coagulation-sedimentation plant handling a river supply. A much larger new plant, which will be constructed by a grant from the national government, is now in the design stage.

The water distribution and sewage collection systems are constructed largely through local initiative. When an extension is desired, the abutting property owners pay *all* costs of materials—pipe, valves, and manhole materials, for example. The Public Works Ministry contributes all labor involved, as construction is done by crews already on the water utility payroll. The typical cost of a 4-in. cast-iron water main in place is given as 170 s/. ($6.30) per lineal meter; 4-in. asbestos-cement pipe in place costs about 100 s/. ($3.70) per lineal meter. These figures include the cost of all valves and other accessories. It was said that the labor cost does not exceed 20 per cent of total installed cost, even though all excavation and backfill are by hand.

At the Huancayo utility, laborers at the lowest wage level receive a base pay of about 650 s/. ($24) per month, boosted by government bonuses for family size, length of service, and cost-of-living adjustments to an average of roughly 1,000 s/. ($37) per month actual take-home pay. A skilled laborer such as the connection crew *gasfiteros* or plumber will receive about 250 s/. ($9) per month more. The chief of the connection crew receives a base salary of 1,420 s/. ($52.60), supplemented by bonuses to 1,930 s/. ($71) per month. The department engineer receives a base salary of 2,630 s/. ($97), to which are added altitude pay,* travel allowance, and other amounts, bringing his total salary to about 4,000 s/. per month, still a very modest $150.

TABLE 2

Rate Schedule—Huancayo, Peru

Category	Minimum Bill		Allowance*	
	soles/month	*$/month*	*cu m*	*gal*
Domestic				
1	9	0.33	30	8,000
2	6	0.22	20	5,000
Commercial-industrial				
1	30	1.11	100	26,000
2	21	0.77	70	18,000
3	12	0.44	40	11,000

* Approximate values. Water used in excess of allowances costs 30 s/. per 100 cu m.

House connections, including the meter, are paid for in advance by the customer. After the full cost of these connections is deposited in the bank, a receipt is taken to the water utility office, and the work order is issued. The cost of a 0.5-in. lead water service is 1,200–1,400 s/. ($44–$52), in-

* Because of the apparently proven shortening of the life span of coastal residents moved to Andean altitudes, professional personnel (only) receive a bonus in excess of the basic civil service pay; the higher the altitude, the larger the bonus.

cluding more than 400 s/. ($14) for a meter. The cost of a 6-in. concrete sewer connection is 400–500 s/. ($14–$18).

In Huancayo, all meters are read by a team of readers, generally from the 25th to the 30th of each month. All bills are then ready by the 10th of the following month. The rate schedule shown in Table 2 is typical of that for utilities operated by the Public Works Ministry. It is essentially a flat-rate schedule, but with a "social" provision for a lower monthly minimum bill to smaller homes. The department engineer is responsible for the classification into categories, about which few objections are raised.

Collection of water bills in Huancayo is assigned to a team of three fulltime employees, who receive 10 per cent of their collections as salary. If the bill remains uncollected after the second call, a warning notice is left. If the customer does not pay the bill by the end of the second month following the meter reading, service is cut off, and not only the bill but also a reconnection charge of 2 s/. (7 cents) must be paid before service is restored. Collections are phenomenal; financial summaries since 1955 show bad accounts of a few hundred soles per year. Many utilities in the United States dream of doing as well.

The office procedures in Huancayo are quite thorough, including a card file of service connections; meter records; preparation of bills by machine; and quite detailed accounting records. A meter test bench and repair shop are also in operation, although in a limited space at present.

Obviously, Huancayo has an unusually well managed water utility, in a progressive city where people want and will pay for good water service.

Point Four Program

The Arequipa project serves as an excellent illustration of the type of aid ICA and PASB are striving for—to help the developing countries help themselves, through the vehicle of the Community Water Supply Development Program.

Polluted water is a killer. Infant death rates in parts of Latin America are shocking. Some of these deaths result partly from unsafe water and partly from lack of water for elementary sanitation. If the public health aspect were not enough, several competent recent studies have shown that a safe and adequate water supply is definitely a good investment. This is true as a result of the savings in time spent carrying water from some distant source and the financial advantage in medical costs avoided and extra income realized because of time spent on the job rather than in the dispensary. Either the economic or the public health advantage alone should be sufficient.

ICA or PASB, however, cannot provide or find funds to meet this need, nor would this be a wise approach. Instead, the most valuable aid that can be given through the Community Water Supply Development Program is stimulus and direction toward making existing water utilities self-supporting; to extract from those benefited reasonable charges for the benefit received, as is the basis of sound management of any utility anywhere.

In Latin America, electric utilities have already established this pattern, along with metering, sound rate schedules, and cutoff in case of nonpayment. There is no reason why water utilities cannot do as well, in the hands of trained administrators with power to

act. A very important point is that in Latin America today, the people of many communities are not only *able* but equally *willing* to pay for good water, once the stiff barrier of first cost is hurdled.

Even with autonomous control and sound management, water utilities in Latin America have great difficulty in finding risk capital for their construction needs. It is here that the international banks enter the picture. The Inter-American Development Bank, aware of the importance of safe and adequate water supply, is considering the financing of a number of water utilities in Latin America. But again, sympathetic as international banks may be toward better water supply, only the soundest of projects can be accepted. This again underlines the principle that the user must pay, and pay enough to make the utility a good financial risk as well as a guardian of the public health. The Point Four Program is providing vital assistance toward these two objectives.

Acknowledgments

The author gratefully acknowledges the valuable assistance and the warm hospitality that he received while in Peru from *Ing.* Jorge Pflucker Holguin, sanitary engineer of the national Ministry of Public Works; *Ing.* Jeronimo Mazzini Chavez, chief of the Ministry's Technical Control Section; and *Ing.* Jose Arrisueno Arispe, sanitary engineering consultant of the ICA staff in Peru.

Correction

The article by Conrad P. Straub, Lloyd R. Setter, A. S. Goldin, and Paul F. Hallbach, "Strontium-90 in Surface Water in the United States" (June 1960 JOURNAL, Vol. 52, pp. 756–68), contained an error. In Table 10, on p. 767, the unit for the activities at Chattanooga should read $\mu\mu c/l$, not *curies*.

Quality Improvements Resulting From Industrial Needs at Hopewell

Elmer F. Eld and Martin E. Flentje

A paper presented on Sep. 15, 1960, at the Virginia Section Meeting, Virginia Beach, Va., by Elmer F. Eld, Mgr., Old Dominion Water Corp., Hopewell, Va., and Martin E. Flentje, Chief San. Engr., American Water Works Service Co., Philadelphia, Pa.

As a result of a request by a large industrial user for a water supply meeting quality standards considerably more stringent than those applied to public drinking water, a 6-year program, involving numerous studies, tests, and plant changes and additions, was undertaken by the Old Dominion Water Corporation, Hopewell, Va. The record of accomplishments of this program may be of interest to others facing similar problems.

The Old Dominion Water Corporation is unique in that it distributes an average of more than 25 mgd but has only 5,000 customers. Of the total water produced, 88.5 per cent is delivered to several large industrial chemical concerns. The high-quality water requested was to be used in producing a premium grade of nitrocellulose.

Origin of System

The Old Dominion Water Corporation owes its existence to the need for gunpowder during World War I. To meet this need, in 1915 a large powder plant—and, with it, a water system—was constructed and operated in the area that is now the city of Hopewell. When the war ended, ths gunpowder plant was shut down but Hopewell continued on as a city and continued to use the original water plant, which had a capacity of 76 mgd. The large lines were of wood stave pipe. The settling basins were small (0.119–0.127 mil gal) and made of steel.

In 1924 approximately half of this plant was taken over by the present Old Dominion Water Corporation, a subsidiary of American Water Works Co.

Description of System

Raw water is obtained from the Appomattox River at a point approximately 1 mi above its confluence with the James River at City Point. At the company's two 36-in. intake lines the watershed of the Appomattox totals 1,450 sq mi. The two rivers are tidal, a fact that plays a large part in the variable character of the water to be treated.

At the low-service river station are located eight raw-water pumps with a capacity of 67 mgd. Two 36-in. lines carry water approximately 1 mi to the high-service station and treatment plant. No treatment is normally applied at the low-service station, although facilities are available to store activated carbon and feed, through two

dry-feed machines, up to 15,000 lb days—a capacity that is sometimes needed.

The treatment plant consists of a circular steel flocculation basin (capacity 127,000 gal), five settling basins (two concrete rectangular and three steel circular, with capacity of 5.25 mil gal), 50 wooden tub filters with a nominal rated capacity of 32.25 mgd, and three clear wells with a capacity of 3.10 mil gal.

Treatment

Present treatment consists of: (1) free residual chlorination, (2) lime addition where needed, (3) application of alum and activated silica, (4) pH correction with lime just ahead of the filters, (5) postchlorination or dechlorination with sulfur dioxide gas as needed, and (6) final pH correction with hydrated lime if needed. All operations are under complete laboratory control and two laboratories are maintained.

The James and Appomattox rivers are tidal, and because of this the character of the water to be treated constantly changes. Chemical tests have shown that the variations are not large, but they have a noticeable effect on the alum dosage required for coagulation, on the chlorine demand, and on the threshold odors when taste and odor problems exist.

Problems and Changes

In 1955, a large industrial customer requested water of considerably better quality than that of the water then being produced. The high-quality water was to be used in the production of a premium grade of nitrocellulose, large quantities being required for washing the product. The character of the water desired, together with the analysis of the water being produced in 1955 and 1960, are shown in Table 1.

The "plug point" is a value determined by placing a standard glass-fiber filter pad (about 4 in. in diameter) in a flanged holder and turning water from the service to be tested into the apparatus at about 50-psi pressure. Flow is allowed to proceed until stoppage occurs, and the amount of water filtered is the plug point. Nitrocellulose producers have apparently determined that a water to be used in washing nitrocellulose destined for premium grade use must have a plug point figure of at least 250 gal. In Hopewell, however, the customer concerned would like to see a much higher figure. Values from 25 gal to more than 850 gal have been obtained at Hopewell with no apparent difference in the character of the water. Since the improvement program began, however, the average plug point figure has increased from about 35 gal to 250–300 gal.

TABLE 1

Desired Quality and Analytical Results on Typical Plant Effluent, 1955 and 1960

Item	Maximum Desired	1955	1960
Fe—*ppm*	0.02	0.30	0.03
Mn—*ppm*	0.005	0.03	0.006
Color	1.0	4	0.0
Turbidity—*ppm*	0.50	0.0–1.0	0.10
Plug point*—*gal*	200	35	100–300

* Amount filtered before a standard glass fiber filter pad (4 in. in diameter) becomes clogged at 50 psi.

The improvement in water quality from 1955 to 1960 was brought about mainly by introducing free residual chlorination, pH correction before filtration, the use of activated silica, the

development of laboratory control procedures, and the provision of laboratory and plant recording instruments.

Chlorination

The change from the use of 150-lb chlorine containers to ton cylinders was made in 1948. At that time, and until 1955, total chlorinator capacity was 1,000 lb/day. In 1955, however, a series of laboratory flocculation studies indicated that prechlorination with considerably larger doses of chlorine than were being applied would result in greatly improved flocculation, as well as better iron and manganese removal. This finding was followed by the installation, over approximately 2 years, of three new chlorinators with a combined feeding capacity of 5,000 lb/day. The plant now has four chlorinators, with a total capacity of 5,500 lb/day. Liquid chlorine is withdrawn from the chlorine container, converted to gas in an evaporator, and the chlorine dose is varied manually to maintain a 4-ppm free chlorine residual directly after application (about 6 min retention time). A chlorine residual recorder is installed in the control laboratory. The change to the free residual method of chlorination resulted in higher chlorine consumption, as is shown in Table 2.

TABLE 2

Average Chlorine Doses, 1954–59

Year	Dose *ppm*
1954	1.46
1955	1.98
1956	2.91
1957	10.48
1958	8.15
1959	8.45

The greatly increased use of chlorine led to the investigation of the possibility of purchasing of chlorine in tank car lots. Such an installation was made in 1959 and has proved eminently successful. Chlorine is now received in 30-ton tank cars.

The 4.0-ppm residual control figure was determined after a careful check of plant operation to obtain optimum iron and manganese removal. The results indicated that heavy prechlorination could be depended on to reduce the iron to 0.04–0.06 ppm and the manganese to 0.01–0.03 ppm, still somewhat higher than the desired industrial standards of 0.02 and 0.005 ppm, respectively. This led to further plant experimentation which indicated that increasing the pH of the settled water just ahead of filtration would bring the concentrations of these elements to less than the desired figures.

Lime Feed Equipment

Coagulation at Hopewell is best carried out at a pH of 6.2 or less (5.4). At these values some iron and manganese will pass the filters. Correction of pH is also desirable for other reasons, such as corrosion prevention, and had been accomplished by adding partially clarified, saturated lime water to the water flowing from the filters to the clear wells. The need to apply lime ahead of filtration and after settling presented a number of problems, as the five settling basins were all at some distance from the coagulant house and no single settled-water line brought water to the 50 filters.

The problem was finally solved by delivering lime slurry from a new lime slaker located in a remodeled lime house nearer to the basins than to the coagulant house. The slurry was delivered, by gravity, through plastic or black steel pipelines.

A change was made from the use of hydrated lime to unslaked, pebble lime (CaO) to obtain some savings and to reduce the volumes of lime needed (unslaked lime contains 93 per cent CaO, whereas hydrated lime contains only 76 per cent).

Material is received by truck in 100-lb bags and is stored on pallets on the ground floor of the newly converted lime house. The lime slaker hopper and feeder on the second floor are fed by a bucket elevator operated from the first floor. The lime dosage averages 17 ppm and provides a pH of 8.2–8.4 on top of the filters and 7.3–7.4 below. The addition of lime at this point has made it possible to produce consistently a filtered water with an iron concentration of 0.02 ppm and a manganese concentration of 0.006 ppm.

The fourth settling basin is 350 ft from the lime house. Lime flows from this location by gravity to all of the settling basin effluent weirs through open troughs or plastic lines. The slurry is pumped to a constant-head box before entering the longest line. No plugging of the pump or lines has been experienced. The lime slurry is kept thicker than at most water plants and a small wire brush is pulled through all 5 lines once each week.

Coagulation

Alum is the coagulant used at Hopewell. In 1955, liquid alum was introduced when an alum-producing chemical company established a plant in Hopewell. The liquid alum is stored in two 12,000-gal rubber-lined steel tanks. These were originally outdoors, but during the second winter of their use some crystallization of alum took place. To prevent such trouble in the future, the tanks were enclosed in a cement block building. The 50 per cent solution of alum is stored and used at full strength. It flows by gravity from the two 12,000-gal tanks through rotometers to a stainless-steel constant-head box. Two pumps deliver the solution to the mixing basin inlet.

The use of liquid alum has been very successful and economical. An annual saving of $25,000 over the use of dry alum has been achieved. The chore of unloading carloads of alum has been done away with, as has the job of emptying bags into the feeders. The accuracy of feed has been greatly improved, and it is believed that there has been a reduction in the dose of alum required for coagulation. The alum solution as received has been of uniform composition, and deliveries are prompt and trouble free. This installation was the first of numerous other liquid alum conversions made in other water utilities under the same management.

The Hopewell plant is deficient in flocculation time and equipment, as are many old plants. It is especially noticeable during the winter months. Various coagulant aids have been tried experimentally, but none except activated silica has shown any promise. Since June 1959, sodium silicate has been used. Its use has resulted in a better formed, tougher floc and the necessary alum dose has been sufficiently reduced to compensate for the added cost. Thus, the use of activated silica has brought no additional cost. The chemical is now obtained in 700-lb drums, but bulk storage is planned for the near future.

Taste and Odor

Until 1956, the Old Dominion Water Corporation had no taste and odor

problems to speak of. In July of that year, however, an odor developed in the raw water and persisted for approximately 2 weeks, but it was controlled by activated-carbon treatment. Again, in July of the following year, similar trouble began. The odor present was described as musty, weedy, and woody. Threshold odor intensities were in the range of 40–60 and, with the plant feeding all the carbon it could at the time (14 ppm), could only be reduced to 18. Sodium chlorite was also being used (0.71 ppm), but its use was discontinued when it was shown to be of no benefit. The plant effluent had a threshold odor of 18, which changed to 20 when the residual chlorine of 1.5 ppm was removed by a dechlorination agent. After dechlorination the odor was described as being a musty, potato bin odor.

A new dry-carbon feeder with a feed capacity of 6,500 lb/day was rushed to Hopewell and put into service. In the meantime, laboratory tests had shown a carbon dose of 60 ppm would be required to produce an acceptable water —that is one with a threshold odor of 4 or less.

This odor difficulty in 1957 lasted slightly more than 3 months and ended when Hurricane Diane dumped enough water on the Appomattox watershed to flush out the streambed thoroughly. Considerable laboratory work was done to determine the cause of this odor, without, however, any conclusive result. Algal growths undoubtedly played a part; the presence of products of decomposition of organic materials was suspected. The amount of carbon used in 1957 totaled 127,000 lb.

The problem of odors has continued to plague the company. No carbon was used in 1958, but 67,000 lb was fed in a 20-day period in 1959. Since Jul. 22, 1960, the trouble has returned greatly intensified. Threshold odors of more than 400 have been present and the application of 15,000 lb/day of carbon has not produced a continuously acceptable water. Serious consideration is being given to the installation of carbon filters for domestic service only.

Conclusion

The foregoing discussion has stressed the physical changes in the Old Dominion Water Corporation treatment plant. Of equal or greater importance has been the development of laboratory control methods that have brought this difficult treatment under much better control. The laboratory is provided with a six-place stirring machine, which gets almost daily use; a colorimeter and photometer; a turbidimeter; and several electrometric pH sets. A recording pH meter will also be installed shortly.

Among the problems that remain to be solved are the determination of the factors that influence the amount of water that can be filtered through a standard plug point filter and the production of an entirely satisfactory water when the increasingly severe tastes and odors occur.

Among other experiments, some plug point tests have been carried out with an all-bronze portable centrifugal pump. Even the small amount of corrosion that would occur in a pump with a cast-iron body was sufficient to result in a plug point test of 20–25 gal for distilled water. The change to a noncorrodible pump raised the figure to more than 1,000 gal. Possibly the best conclusion to be reached from this experience is that water treatment procedures and facilities are extremely versatile and efficient and, operated intelligently, can overcome many treatment difficulties.

Viruses, Amebas, and Nematodes and Public Water Supplies

Shih Lu Chang

A paper presented on Nov. 3, 1960, at the Chesapeake Section Meeting, Washington, D.C., by Shih Lu Chang, Medical Director, Water Supply & Water Pollution Research, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

SANITARY engineers have been very successful in eliminating waterborne bacterial diseases in municipalities. This is particularly true in the United States—so much so that no matter where one goes in this country, he can drink a glass of municipally supplied water without fear of contracting bacterial diseases.

As waterborne bacterial diseases continue to decline and the bacteriologic quality of water supplies continues to improve, waterborne infectious hepatitis attracts more and more attention of public health and sanitary workers. Municipal water supplies are found to carry, not infrequently, live free-living nematodes and amebic cysts. Hence, it is timely to examine critically the literature and current research on these microbes to evaluate the public safeguards against municipally waterborne virus diseases and the provision of high-quality public water supplies. If they are necessary, what preventive or remedial measures should be taken?

Biologic Characteristics

As water utility operators often have not had the occasion to study viruses, amebas, and nematodes, some notes on their basic biologic characteristics may be helpful:

Viruses. Viruses, the smallest and simplest living organisms, are 10–450 mμ in size. Although most of the animal viruses are round, some plant and bacterial viruses have the shape of a brick, cylinder, filament, or tadpole. The smaller viruses are visible only by electron microscopy and will pass through bacteriologic filters.

Strictly parasitic, viruses grow only inside appropriate host cells in a living stage. Early studies of animal viruses were done with laboratory animals and chick embryos, but, today, virus research has developed greatly by the use of tissue cultures of monkey kidney or other mammalian cells. Virus growth in tissue cultures results in degeneration of host cells as seen under a microscope and forms "plaques" in a host cell sheet visible to the naked eye.

Not all animal viruses infect laboratory animals, chick embryos, or tissue cultures. For instance, the infectious-hepatitis virus infects only humans and, therefore, does not lend itself to laboratory investigations.

Amebas. Amebas are single-cell microscopic animals, mostly 10–30 μ in diameter. Their life cycle includes a growing and a resting stage. Growing amebas lack a cell wall and move around by the formation of protru-

sions. Resting, they form cysts, more resistant to environmental changes than the ameboid form.

Although most amebas are free living in soil, water, and related habitats, a few are parasitic to man and animals. The most important parasitic ameba of man is *Endameba histolytica,* the causative agent of amebic dysentery, transmitted usually in the cystic stage.

Nematodes. Nematodes (roundworms) are multicellular animals without internal segmentation but with separate sex. Those that parasitize man and animals are visible to the naked eye; but the free-living forms found in fresh water, soil, and related habitats are microscopic (0.02–0.05 mm wide and 0.5–2.5 mm long). Their life cycle includes mating, egg laying or egg bearing, hatching of eggs, and the development of larvae and adults. In some free-living nematodes, propagation takes place without the male.

Although many nematodes infect man and animals, thousands are free-living normal fauna in natural waters, soil, and related habitats, such as trickling filters and activated sludge. Some appear to be "clean water" inhabitants, and others, such as those of the Rhabditidae family, abound in aerobic sewage treatment facilities. The most remarkable feature of these free-living nematodes is their high resistance to free chlorine.

Viruses

Infectious-hepatitis virus. In a recent review, Clarke and Chang [1] presented data on the number and extent of waterborne epidemics of infectious hepatitis reported in the United States and abroad. A more complete listing was given in a later report by Mosley,[2] in which a total of 28 outbreaks were recounted. At a conference of the Michigan Department of Health—held on Oct. 23, 1959, at Lansing, Mich.—a waterborne outbreak of infectious hepatitis was reported to have occurred in Posen, Mich.; 89 cases were recorded during April and May 1959. Herold [3] recently reported an outbreak in West Virginia in May 1960, during which 53 cases occurred within a 2-week period in a school. The epidemic was attributed to the contamination of one of the two deep wells that supplied water to the school; the contamination was the result of clogging of the sewerage system in heavy rain during the preceding month.

Of particular interest is the fact that of all the peacetime hepatitis outbreaks, only two were associated with the use of municipal water supplies; the others involved chlorinated or unchlorinated small supplies. One of the two city outbreaks is the well known New Delhi, India, epidemic of 1955–56, comprising a total of 28,745 reported cases.[4, 4a] The other municipal outbreak occurred in 1944–45 in a town of 60,000 people on Tidal River in Pennsylvania.[5] In both epidemics, gross sewage pollution of the raw water was blamed, and concurrent enteric bacterial diseases were not recorded. Although bacteriologic results for the treated water were considered satisfactory, at least in the New Delhi case, it has been suggested that the bacteriologic data were too meager to support any such conclusion.

It appears, then, that waterborne outbreaks of infectious hepatitis resulting from the use of municipally treated water supplies are unlikely. These outbreaks may occur, however, if the raw source is so grossly polluted by domestic sewage that the concentration of viral agents is such that it cannot be

reduced below infectious levels by the treatment procedures available to the local water system. Under such circumstances, satisfactory results of bacteriologic tests could be considered as a safety index for enteric bacterial, but not viral, diseases.

Enteroviruses. Enteroviruses—comprising 3 types of poliovirus, 30 types of Coxsackie virus, and 24 types of ECHO virus—are so called because they multiply in the human intestine and are discharged chiefly in the feces. As previously stated,[1] of all the enterovirus infections recorded, only two waterborne outbreaks have been reported, both of poliomyelitis. The 1953 epidemic in Edmonton, Canada,[6] was believed to be waterborne because: (1) the outbreak was of an explosive type, with scattered cases throughout the city; (2) the outbreak correlated in time with failures of the chlorination equipment used in treating the settled sewage of Devon, Canada—sewage that was discharged into the North Saskatchewan River from which Edmonton drew its raw water; and (3) poliovirus was recovered from the Devon sewage. Like the New Delhi epidemic of infectious hepatitis, concurrent outbreaks of enteric bacterial diseases were not recorded.

The other outbreak occurred in 1952 in Huskerville near Lincoln, Neb.[7] Although water department records do not appear to bear it out, the outbreak was attributed to sewage contamination of the water distribution system by back siphonage. The epidemiologic evidence appeared to have been strengthened somewhat by the finding of coliform organisms in the tap water of the involved area.

The complete absence of waterborne outbreaks of the Coxsackie and ECHO virus infections is certainly an extraordinary phenomenon. Explanations have to wait until the disease process of these organisms is better understood and the epidemiology more thoroughly investigated.

Adenoviruses. Although adenoviruses belong to the respiratory group of viruses, they apparently multiply in the human gut and are found, therefore, in significant amounts in feces and recovered in sewage. As stated before,[1] waterborne adenovirus infections have not been reported, but three outbreaks have been associated with the use of swimming pools.

Other viruses. A variety of nonenteric viruses, such as influenza, encephalitis, and rabies viruses, have been occasionally isolated from feces of infected persons. As the presence of the influenza virus in feces is apparently a result of the swallowing of respiratory discharge, and the presence of the others accidental, water need not be seriously considered as a vehicle of these viruses.

As has been pointed out in the previous report,[1] the salivary gland virus has been isolated from the urine of healthy children. Very recently, the measles virus has also been successfully isolated from the urine of children in the first few days of the illness.[8] These viruses, therefore, should find their way into sewage or sewage effluent. As these infections occur generally in early childhood through personal contact, no significance should be attached to the finding of these viruses in children's urine.

Amebas

Endameba histolytica. To date, only four waterborne outbreaks of amebiasis have been recorded in the literature. The well known Chicago epidemic in 1933,[9] the Tokyo Mantetsu Apartment

Building epidemic in 1947,[10] and the more recent South Bend, Ind., epidemic in 1953 [11] were all traced to the sewage contamination, due to faulty plumbing systems, of local distribution systems of public water supplies. The Chicago Stockyard Fire outbreak among firemen and spectators in 1934 [12] resulted from the drinking of grossly sewage-polluted water used for feeding animals in the stockyards and was associated with the occurrence of enteric bacterial diseases. These outbreaks indicate that raw water heavily contaminated with domestic sewage is a potential source of amebiasis, but that municipal water supplies are not likely to be involved unless there exists local contamination of the distribution system.

Free-living amebas. In a recent survey to determine the presence of free-living nematodes and amebas in municipal water supplies in the United States, live cysts of free-living amebas of the genera *Naegleria* and *Hartmannella* were found in small numbers in 6 of 22 supplies examined.[13] As these amebas are normal fauna of natural fresh waters and can easily establish colonies where food is available, and as the origin of these waterborne cysts was not ascertained, the sanitary significance of their presence could not be evaluated. Being free living and nonpathogenic, they are not involved in human illness. They may ingest a few pathogenic enteric bacteria, but these are rapidly digested in the trophozoites.[14] The amebas do not serve as carriers of enteroviruses.[14]

Nematodes

Parasitic nematodes. Municipal water supplies are not known to be involved in spreading infections by any nematode. But small rural supplies in certain endemic areas could carry hookworm or strongyloidal larvae washed into the water from infected soil. These supplies constitute a mode of transmission of minor importance as compared to the soil itself. In areas in Africa, Arabia, and India, small, open wells, step wells, and temporary cisterns accessible to infected persons constitute the main source of infection by the guinea worm (a filarial worm) through the copepods, which serve as the intermediate host of this nematode.

Free-living nematodes. Early in 1918, Cobb [15] found that free-living nematodes extensively inhabited slow sand filter beds and estimated that hundreds of millions of the nematodes were present in the top 3-in. layer of sand in an acre area. He thought that the excreta of these nematodes affected the flavor of the water and might be a cause of intestinal disturbances.

Interest in this subject gradually declined, apparently with the replacement of slow sand filters by rapid sand filters. It was not until 1955 that Kelly [16] reported the presence of the nematode *Trilobus gracilis* and other zoologic organisms in the Norwich, England, tap water at a time when the city supply was heavily infested with the bristle worm *Nais.* Of interest is the finding of these worms in tap water filtered through slow sand filters but not in water filtered through rapid sand filters.

The report of the occurrence of free-living nematodes in a large city water supply in the Ohio River Valley in 1955 [17] revealed the existence of the nematode problem in water utilities employing rapid sand filtration. The findings of a recent survey of 22 city water supplies for free-living nematodes and amebas [13] indicated that the nematodes are relatively common in

municipal water supplies from surface sources. Of the 22 treated supplies examined, 16 contained nematodes. Rivers were a source for 14 of these 16 supplies. It was believed that the nematodes in the majority of the supplies came from the raw water. In one or two supplies, the breeding of nematodes in the treatment plant was suspected.

Being free living and nonpathogenic to man, these nematodes themselves have no health significance. It has been shown,[18] however, that two species (*Cheilobus quadrilabiatus* and *Diplogaster nudicapitatus*) of the Rhabditidae family, isolated from treated water supplies and present in large numbers in the effluent of trickling filters and the activated-sludge process, were capable of ingesting *Salmonella* and *Shigella* bacteria and Coxsackie virus. Of the ingested pathogens, 6–16 per cent survived for 1 day; 0.1–1 per cent survived for 2 days. These nematodes were so resistant to free chlorine that a 2.5–3.0-ppm residual failed to immobilize them in 120 min; a 15–45-ppm residual failed to immobilize them in 1 min. The ingested pathogens were protected to the extent that they all survived even when 90 per cent of the carrier worms were immobilized.

On the basis of these findings, it was thought that nematodes of aerobic sewage treatment origin could serve as carriers of human enteric pathogens. Under normal conditions, however, the chances of nematodes ingesting the pathogens in the treatment plant and being carried by the polluted water through the water system in a day are so small that the possibility must be considered as very remote.

The possible role of free-living nematodes in imparting odor and taste to water supplies, as suggested by Cobb,[15] has definite laboratory support if the nematodes propagate in the treatment plant. In another report [19] on the growth and life cycle of several rhabditid nematodes, it was shown that cultures of these nematodes, with or without associated bacteria, had a strong, earthy, musty odor. A gummy substance extracted from these cultures imparted a distinct odor to water in dilutions of 1:20,000. In slow sand filters with a large population of nematodes, it appears that a substantial contribution to the odor and taste of the water could occur.

The toxic effect of the nematode excreta on the intestinal tract, as was expected by Cobb,[15] could not be demonstrated. White mice, fed with fluid from bacteria-free cultures of four rhabditid nematodes in amounts of 1 ml per mouse, showed no signs or symptoms of gastrointestinal disturbances.

Incidence of Disease

The incidence of infectious hepatitis in the United States has been cyclic since the disease was included, in 1952, in the list of diseases published in the USPHS *Morbidity and Mortality Weekly Reports.* In the year ending Sep. 3, 1960, nearly 34,000 cases were reported—a 62 per cent increase over the cases reported in the preceding year.[20] It should be noted that relatively small numbers of these cases were contributed by outbreaks. The great majority of cases were sporadic and of undetermined origin.

Could these sporadic cases have been infected through foods or personal contact? Or could they have been infected through water supplies that contained such low virus concentrations that people became infected at random? At the present, epidemi-

ologic evidence points to personal contact as the major route of transmission. Only carefully controlled long-term epidemiologic studies in carefully selected communities, with the quality of the treatment of water supplies as the only major variable to be investigated, can provide information for ascertaining the role of water in the occurrence of these cases now of unknown origin.

Although municipal water supplies are very unlikely to become involved in waterborne infectious hepatitis outbreaks, the waterborne epidemics at New Delhi, India, and the Tidal River in Pennsylvania serve as warning that this remote possibility may become real if municipal supplies use heavily polluted water as their source of raw water. In such situations, the adequacy of water treatment in preventing outbreaks of infectious hepatitis may not be indicated by satisfactory bacteriologic results.

Epidemiologists have been, and are still, skeptical of waterborne enterovirus infections. Indeed, it is highly perplexing that viruses discharged chiefly in feces and found in sewage and sewage effluent whenever they are looked for have, so far, been responsible for only two outbreaks reported as waterborne (poliomyelitis at Edmonton, Canada, and Lincoln, Neb.). It is even more perplexing that no waterborne infectious-hepatitis outbreaks concurred with enterovirus infections, for these viruses are known to be much more resistant to chlorine than are the coliform bacteria.[1]

Although the puzzle may not be solved for quite some time, the Edmonton epidemic of poliomyelitis suggested, too, the possibilities that municipal supplies drawing their raw source from heavily polluted water could precipitate outbreaks of this disease even when the bacteriologic results indicate a satisfactory treatment. In view of the mass vaccination against polio, it is apparent that the small probability of waterborne poliomyelitis will be even further reduced. But its existence under these circumstances would add support to the danger of waterborne infectious hepatitis.

As stated before, waterborne outbreaks of amebiasis have been associated only with sewage contamination of the distribution system. Under these conditions, sufficient numbers of cysts may be carried in the tap water to initiate the disease process. The fact that the ratio of cyst density to that of coliform organisms in sewage (estimated on the basis of a 10 per cent cyst carrier rate) is approximately 1:100,000 [21] and that cysts tend to settle out in sewage, sewage effluent, and water [22] may very well explain the unlikelihood of waterborne amebiasis associated with municipal water supplies using even heavily polluted water as their raw source. This explanation is strengthened by the absence of a concurrent outbreak of amebiasis in both the New Delhi and the Tidal River epidemics of infectious hepatitis and in the Edmonton outbreak of poliomyelitis, and also by the failure to find cysts of *Endameba histolytica* in the Chanute, Kan., water supply at the time it was using "reclaimed" water as its source.[23]

Free-living amebas themselves have no health significance. What the presence of live cysts in the finished water implies in the way of adequacy of treatment remains to be ascertained.

Role of Nematodes

Although the possible role of free-living nematodes in imparting odor

and taste to, and carrying enteric pathogens in, municipal water supplies has been discussed previously,[13] the problem related to the occurrence of nematodes in water is apparently an aesthetic one. Unless slow sand filtration is used in the treatment process, as described by Cobb,[15] the amount of odorous material of nematode origin present in the water is very unlikely to impart an odor. The possibility that nematodes propagated during sewage treatment are carriers of enteric pathogens has, so far, been found to be very remote indeed. Of the samples of sewage effluent collected (from trickling filters or the activated-sludge process) from five treatment plants located along the Ohio River, all contained nematodes—mostly *Rhabditis, Diplogaster,* and *Dorylaimus,* in numbers ranging from 200 to 2,000 per gallon. Attempts to isolate *Salmonella* and *Shigella* organisms and enteroviruses in these nematodes have all been unsuccessful, although coliform bacteria were present in detectable numbers.

On the other hand, it is hard to conceive that water is of high quality if every glass of it contains a few worms, even though they are invisible to the naked eye. This was the basis of the suggestion made in a previous report[13] that when the nematode concentration in the finished water exceeds ten per gallon, the source should be investigated and remedial measures effected. In this connection, it may be pointed out that in the current study of free-living nematodes in the effluent of trickling filters and the activated-sludge process—a study made at the Robert A. Taft Center in Cincinnati—the number of nematodes from this source alone has been found to be sufficient to account for about three-fourths of the nematode population in Ohio River water.

Preventive Measures

Viruses. There is very little doubt that the best measure to prevent municipal waterborne infectious hepatitis and, possibly, poliomyelitis is to avoid the use of grossly polluted water as a source of public supplies. With regard to the New Delhi epidemic,[4] it was estimated that for several days in the early part of the epidemic, sewage amounted to as much as 50 per cent of the water used in the supply.

When heavily polluted water must be used as a source of public supply, prechlorination of the raw water is suggested at such dosages that 0.3–0.4 ppm of free residual is maintained during the entire treatment and 0.2–0.3 ppm at the time the water leaves the treatment plant. On the basis of the available information reviewed in a previous report,[1] the chances of survival of any of the human enteric viruses under these chlorination conditions are very small indeed. If the water treatment process includes satisfactory flocculation, another 90–99 per cent virus removal should be added to the total efficiency.

Outbreaks of infectious hepatitis involving small or private supplies have been accidental. A certain weakness in the supply system existed owing to the type of source, such as an unprotected well or spring, or partial treatment under loose supervision. With carriers or cases introduced into the local population, and certain climatic changes or events helping the process along, the water supplies have become contaminated by sewage, thus resulting in outbreaks. Preventive measures in very small supplies, such as in villages and private sources, are very difficult.

But in small towns, improvement of the water treatment and installation of a sewage treatment plant or improvement of existing sewage facilities certainly is an effective measure.

Endameba histolytica. The fact that there have been, so far, three outbreaks of amebiasis involving municipal water supplies and all the outbreaks were traced to sanitary defects in the plumbing system indicates clearly that the preventive measures are of a local type, such as the disconnection of a cross connection or the prevention of sewage seepage into a supply main. It may be pointed out that there have been no further cases of amebiasis related to two Chicago hotels since sanitary defects in their plumbing systems were corrected after a 1933 epidemic.

Free-living nematodes. When slow sand filtration is used in the treatment process, no effective measures are foreseen for preventing nematode infestation in the finished water, except the replacement of the slow sand filters by rapid sand filters. When nematodes are carried in raw water in large numbers (approximately 50 per gallon), remedial measures seem to be desirable. Studies along this line are still underway at the Taft Center. Results thus far indicate that both silver ion and elemental iodine are definitely more nematodicidal than HOCl, but effective dosages are too high to be practical. Neither has been recommended for treating municipal supplies.

At present it appears that the most practical method for preventing nematode infestation is to prechlorinate the raw water for 6 hr; a free residual of 0.4–0.5 ppm chlorine should result at the end of this period. Although many of the nematodes are not killed, they are sufficiently affected so that they can no longer swim; therefore, they will be settled out in the flocculation process. The pH, in the range of 6.0–8.2, appears to have no detectable influence on the vermicidal activity of the free chlorine.

Editor's Note

For the light that has been shed on viruses, amebas, and nematodes—strangers to most water works operators—Dr. Chang is to be warmly applauded. We do wish to emphasize, however, that involvement of any of these organisms in disease borne by public water supplies is in most cases still a matter of speculation. As pointed out by Wolman, in discussing the New Delhi epidemic of infectious hepatitis, for instance, it was "apathetic control, lack of hour-to-hour alertness, administrative jealousy and competition, and failure to adjust promptly to catastrophic conditions" more than any known failure of water treatment procedures that was involved. Similarly, in the Huskerville outbreak of poliomyelitis, water department pressure records contradict the supposition that back siphonage could have occurred.

The importance of this article is that it provides information that water works men need about the epidemiologic suspicions concerning waterborne disease. The fact that some of these suspicions are based on engineering information that has been questioned does not destroy its value as far as the operator is concerned. The intent here is merely to point out that the epidemiologic view and the practical water works operating view must be different. In his research, Dr. Chang very properly looks with suspicion on anything that is not completely explained—in other words, he considers no possibility too remote to warrant investigation. The water works operator, on the other hand, although aware of such suspicions and investigations, cannot act as if every possibility were a fact or he would supply no water. He must consider what is likely rather than what is possible—in other words, he must calculate the risk. And the record of the industry in its calculations is not such that it should now panic.

Acknowledgment

The author is indebted to Paul W. Kabler, chief of microbiology at Taft Center, for reading the article and making helpful suggestions.

References

1. Clarke, N. A. & Chang, S. L. Enteric Viruses in Water. *Jour. AWWA,* 51:1299 (Oct. 1959).
2. Mosley, J. W. Waterborne Infectious Hepatitis. *New Engl. J. Med.,* 261:703, 748 (1959).
3. US Public Health Service. *Morbidity & Mortality Weekly Reports,* 9: No. 37 (Sep. 23, 1960).
4. Viswanathan, R. Infectious Hepatitis in Delhi (1955–56): Epidemiology. *Indian J. Med. Research,* 45:1 (1957).

4a. Dennis, J. M. 1955–56 Infectious Hepatitis Epidemic in Delhi, India. *Jour. AWWA,* 51:1288 (Oct. 1959).

5. Hayward, M. L. Epidemiological Study of Outbreak of Infectious Hepatitis. *Gastroenterology,* 6:504 (1946).
6. Little, G. M. Poliomyelitis and Water Supply. *Can. J. Pub. Health,* 45:100 (1954).
7. Bancroft, P. M.; Engelhard, W. E.; & Evans, C. A. Poliomyelitis in Huskerville (Lincoln), Neb. *J. Am. Med. Assn.,* 164:836 (1957).
8. Gresser, I. & Katz, S. L. Isolation of Measles Virus From Urine. *New Engl. J. Med.,* 263:452 (1960).
9. Epidemic of Amebic Dysentery: The Chicago Epidemic in 1933. *Nat. Inst. Health Bul.* 166, US Govt. Printing Office, Washington, D.C. (1936).
10. Ritchie, L. S. & Davis, C. Parasitological Findings and Epidemiological Aspects of Epidemic Amebiasis Occurring in Occupants of the Mantetsu Apartment Building, Tokyo, Japan. *Am. J. Trop. Med.,* 28:803 (1948).
11. Offutt, A. C.; Poole, B. A.; & Fassnacht, G. G. A Waterborne Outbreak of Amebiasis. *Am. J. Pub. Health,* 45:486 (1955).
12. Hardy, A. V. & Specttor, B. K. The Occurrence of Infestations With *E. histolytica* Associated With Waterborne Epidemic Diseases. *Pub. Health Repts.,* 50:323 (1935).
13. Chang, S. L.; Woodward, R. L.; & Kabler, P. W. Survey of Free-Living Nematodes and Amebas in Municipal Supplies. *Jour. AWWA,* 52:613 (May 1960).
14. Chang, S. L. Growth of Small Free-Living Amebas in Various Bacterial and in Bacteria-Free Cultures. *Can. J. Microbiol.,* 6:397 (1960).
15. Cobb, N. A. Filter-Bed Nemas-Nematodes of the Slow Sand Filter Beds of American Cities. *Contrib. Sci. Nematol.,* 7:189 (1918).
16. Kelly, S. N. Infestation of the Norwich, England, Water System. *Jour. AWWA,* 47:330 (Apr. 1955).
17. Chang, S. L., et al. Occurrence of a Nematode in a City Water Supply. *Jour. AWWA,* 51:671 (May 1959).
18. Chang, S. L.; Berg, G.; & Clarke, N. A. Survival and Protection Against Chlorination of Human Enteric Pathogens in Free-Living Nematodes Isolated From Water Supplies *Am. J. Trop. Med. & Hyg.,* 9:136 (1960).
19. Chang, S. L. Cultivation and Life Cycle of Rhabditid Nematodes. *Can. J. Zool.* (*in press*).
20. US Public Health Service. *Morbidity & Mortality Weekly Reports,* 9: No. 35 (Sep. 3, 1960).
21. Chang, S. L. & Kabler, P. W. Detection of Cysts of *Endameba histolytica* in Tap Water by the Use of Membrane Filter. *Am. J. Hyg.,* 64:170 (1956).
22. Chang, S. L. Some Epidemiological and Biological Problems in Waterborne Amebiasis. Symposium on Limnological Aspects of Water Supplies and Waste Disposal at meeting of Am. Assn. for Advancement of Sci., Chicago (Dec. 1948).
23. Metzler, D. F., et al. Emergency Use of Reclaimed Water for Potable Supply at Chanute, Kan. *Jour. AWWA,* 50:1021 (Aug. 1958).

Occurrence of ABS in Water Supplies

Joint Discussion

Two contributions to the Journal on the subject of ABS in water supplies.

ABS in Drinking Water in the United States
AASGP Committee Report

A report by the Subcom. on ABS in Drinking Water, Tech. Advisory Council Steering Com., Assn. of Am. Soap & Glycerine Producers, New York, N.Y., submitted by Richard C. Jente (Chairman), Asst. Director, Production-Sales Control, Inorganic Chemicals Div., Monsanto Chemical Co., St. Louis, Mo. Other members of the subcommittee are Russell Bell, F. J. Coughlin, W. K. Griesinger, W. L. Jensen, J. D. Justice, W. A. Kline, H. V. Moss, E. G. Paulson, and J. T. Rutherford.

THE Association of American Soap and Glycerine Producers (AASGP), New York, through a research program initiated in 1955, began studies related to traces of alkyl benzene sulfonate (ABS) that may find their way into rivers and public water supplies through the use of household detergents. ABS is the sodium salt of commercial sulfonated dodecylbenzene and is the most commonly used synthetic surface-active agent in formulated household synthetic detergents. A technical subcommittee was formed in 1959 to establish quantitatively the concentrations of ABS that may be present in municipal drinking water supplies.

With the use of recognized surveys,[1-4] a study was prepared of the normal varieties of drinking water supplies in 32 cities throughout the United States (Fig. 1). The selection of test cities was based on raw-water source, location, treatment method, and population. The cities chosen represent roughly one-eighth of the population of the United States.

Sampling

Samples were taken in the summer (Series A), during the period in which normal rainfall and, therefore, runoff are low; in early winter (Series B), when runoff is usually relatively low; and in the spring (Series C), during the customary high-water period. It may be recalled that during the period of sampling for Series B, the eastern seaboard was having unusually heavy rains, with flooding in some areas. No excesses in weather were noted during the sampling for Series A and C.

One-quart samples were collected in new polyethylene bottles by committee members and mailed to the chairman.

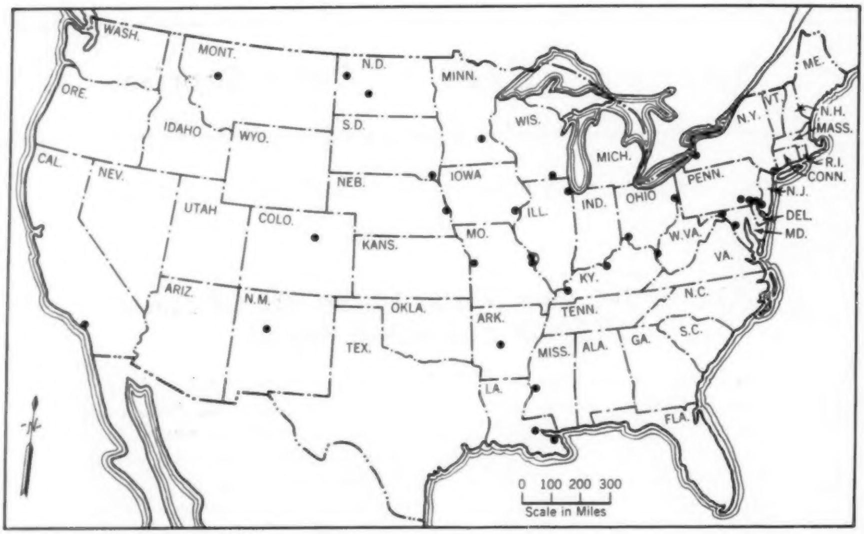


Fig. 1. Cities Sampled in AASGP Study

The 32 cities sampled represent approximately one-eighth of the population of the United States.

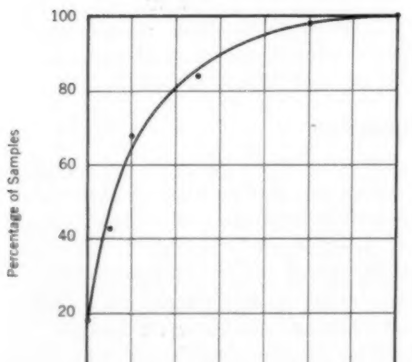


Fig. 2. Results of ABS Analyses

Shown is the percentage distribution for all samples in the study.

An experienced, independent testing laboratory performed the analyses for ABS using the methylene blue method.[5] The laboratory selected to make the analyses is currently offering this service on a routine basis; the same analyst performed all analyses.

ABS Analysis

It is recognized that the methylene blue method is subject to positive interferences when used in analyzing surface water samples.[5] The results of some of the treated water samples may have been affected by positive interferences. Even if this occurred, the values in Table 1 are all so low that any interferences can be considered unimportant.

To insure validity of results, the accuracy of the method and reliability

TABLE 1

ABS Content of Drinking Water

City	Approximate Population Served *1,000's*	Water Source	Water Treatment Methods*	Series A		Series B		Series C	
				Sampling Month, 1959	ABS *ppm*	Sampling Month, 1959	ABS *ppm*	Sampling Month, 1960	ABS *ppm*
Albuquerque, N.M.	97	well	1	Aug.	0.04	Nov.	0.02	Mar.	<0.01
Baton Rouge, La.	126	well	2	Jul.	0.02	Nov.	0.00	Mar.	0.00
Camden, N.J.	125	well	3	Jun.	0.14	Oct.	0.02	Mar.	<0.01
Janesville, Wis.	25	well	†	Jul.	0.01	Nov.	0.00	Mar.	0.00
Buffalo, N.Y.	580	Lake Erie	4	Aug.	0.01	Oct.	0.02	Mar.	<0.01
Chicago, Ill.	3,600	Lake Michigan	5	Jun.	0.03	Oct.	<0.01	Mar.	<0.01
Boulder, Colo.	20	glacier	†	Jul.	0.01	Oct.	0.02	Mar.	<0.01
Little Rock, Ark.	105	alum fork of Saline River	6	Jun.	0.00	Nov.	0.00	Mar.	0.00
New York, N.Y.	8,100	reservoirs (Catskill, Croton, Delaware River)‡	7	Jun.	0.00	Oct.	0.02	Mar.	<0.01
Los Angeles, Calif.	3,560	Colorado River‡	5	Jul.	0.00	Nov.	0.02	Mar.	0.00
Minneapolis, Minn.	540	Mississippi River§	8	Jun.	0.02	Nov.	0.01	Mar.	<0.01
Burlington, Iowa	32	Mississippi River§	8	Jul.	0.02	Nov.	0.04	Mar.	0.02
St. Louis, Mo.	860	Mississippi River§	9	Jun.	0.02	Nov.	0.05	Mar.	0.04
Vicksburg, Miss.	28	Mississippi River§	8	Jul.	0.03	Nov.	0.03	Mar.	<0.01
New Orleans, La.	570	Mississippi River§	5	Jul.	0.02	Nov.	0.06	Mar.	<0.01
Great Falls, Mont.	44	Missouri River§	10	Jul.	0.00	Dec.	0.00	Mar.	<0.01
Williston, N.D.	7	Missouri River§	4	Aug.	0.02	Nov.	0.00	Mar.	0.00
Bismarck, N.D.	20	Missouri River§	10	Jul.	0.01	Nov.	0.00	Mar.	0.00
Yankton, S.D.	11	Missouri River§	4	Aug.	0.02	Nov.	0.02	Mar.	<0.01
Omaha, Neb.	264	Missouri River§	8	Jun.	0.05	Dec.	<0.01	Mar.	<0.01
Kansas City, Mo.	690	M'ssouri River§	10	Jun.	0.00	Oct.	0.02	Mar.	0.06
St. Charles, Mo.	15	Missouri River§	8	Jun.	0.02	Dec.	0.05	Mar.	0.06
East Liverpool, Ohio	31	Ohio River§	5	Jun.	0.09	Sep.	0.04	Apr.	0.02
Huntington, W.Va.	120	Ohio River§	10	Jul.	0.06	Nov.	0.02	Mar.	<0.01
Cincinnati, Ohio	634	Ohio River§	5	Jun.	0.03	Oct.	0.04	Mar.	0.02
Louisville, Ky.	450	Ohio River§	5	Jul.	0.06	Nov.	0.08	Mar.	0.03
Paducah, Ky.	37	Ohio River§	5	Jun.	0.02	Nov.	<0.01	Mar.	<0.01
Hagerstown, Md.	30	Potomac River§	5	Jun.	0.07	Nov.	0.02	Mar.	0.01
Washington, D.C.	1,000	Potomac River§	5	Jun.	0.03	Nov.	0.02	Mar.	0.01
Pottstown, Pa.	30	Schuylkill River§	10	Jun.	0.05	Nov.	0.04	Mar.	0.02
Norristown, Pa.	55	Schuylkill River§	5	Jun.	0.07	Nov.	0.04	Mar.	0.04
Philadelphia, Pa.	1,100	Schuylkill River§	4	Jun.	0.12	Nov.	0.04	Mar.	<0.01
Average					0.034		0.024		0.015

* Numerals indicate the following: (1) chlorination; (2) partial chlorination; (3) partial aeration; (4) coagulation, sand filtration, and partial chlorination; (5) prechlorination, coagulation, sand filtration, partial chlorination, and activated-carbon treatment for taste and odor control; (6) coagulation, sand filtration, and chlorination; (7) coagulation and chlorination; (8) prechlorination, coagulation, sand filtration, and partial chlorination; (9) prechlorination, two-stage coagulation and sedimentation, sand filtration, and partial chlorination; and (10) coagulation, sand filtration, partial chlorination, and activated-carbon treatment for taste and odor control.

† No treatment methods.

‡ Little or no upstream pollution.

§ Repeated stream use for both water supply and waste disposal.

of the operator were checked with two samples included with Series C samples for analysis. One sample was distilled water; the other was distilled water with 0.10 ppm ABS added.

In Series A, B, and C, all samples were analyzed within 30 days of sampling. Analyses were made in triplicate for both check samples; all other samples were analyzed only once. Results of the check analysis (Table 2) show that replicate analyses were accurate to 0.01 ppm ABS in distilled water containing 0.10 ppm added ABS.

Summary of Data

Results of the investigation (Table 1 and Fig. 2) can be summarized as follows: 100 per cent of the samples exhibited ABS concentrations equal to

TABLE 2

Results of Check Analysis

Sample*	ABS Concentrations Found in Triplicate Analyses *ppm*
Distilled water with 0.10 ppm ABS added	0.09, 0.10, 0.09
Distilled water	0.00, 0.00, 0.00

* Samples were prepared on Mar. 21, 1959, and analyzed on Apr. 14, 1959.

TABLE 3

ABS Concentration During the Three Sampling Periods

Series	Avg ABS Concentration *ppm*
A (summer)	0.034
B (winter)	0.024
C (spring)	0.015

or less than 0.14 ppm ABS; 98 per cent of the samples, equal to or less than 0.10 ppm ABS; 84 per cent of the samples, equal to or less than 0.05 ppm ABS; 68 per cent of the samples, equal to or less than 0.02 ppm ABS; and 43 per cent of the samples, equal to or less than 0.01 ppm ABS. The ABS concentration during the three sampling periods indicated its relationship to streamflows as influenced by rainfall and runoff (Table 3), for the average ABS content for each sampling showed a maximum during the summer (Series A) and a minimum during the spring (Series C).

General Conclusions

The ABS concentration in the drinking waters tested is extremely low. The average for all samples analyzed was 0.024 ppm ABS, in a range of 0.00–0.14 ppm and with 98 per cent of the samples not exceeding 0.10 ppm. The ABS concentration in the water supplies tested is highest during the summer and lowest in the spring, as might be expected from seasonal effects of rainfall and runoff.

References

1. Quality of Surface Waters of the United States. *USGS Water Supply Papers* 1250, 1251, and 1253. US Govt. Printing Office, Washington, D.C. (1952).
2. The Industrial Utility of Public Water Supplies. *USGS Circ.* 197, 203, 206, 221, 232, 253, 269, 283, and 288. US Govt. Printing Office, Washington, D.C. (1952).
3. Annual Reports 5, 6, 7, and 8. Ohio River Valley Water Sanitation Com., Cincinnati (1953–58).
4. Water Quality and Flow Variations in the Ohio River, 1951–55. Ohio River Valley Water Sanitation Com., Cincinnati (1955).
5. Task Group Report. Determination of Synthetic Detergent Content of Raw-Water Supplies. *Jour. AWWA*, 50:1343 (Oct. 1958).

ABS in Michigan Supplies—Gordon E. Olivier

An excerpt from a paper presented on Sep. 21, 1960, at the Michigan Section Meeting, Traverse City, Mich., by Gordon E. Olivier, San. Engr., Water Supply Sec., Div. of Eng., State Dept. of Health, Lansing, Mich.

A great deal of evidence has been advanced in the literature on specific situations in which ABS has been detected in both ground and surface waters. This is not surprising when one remembers that ABS, unlike soap, resists degradation by waste treatment facilities and by natural forces in rivers, lakes, and subsurface aquifers. In fact, it is logical that surface water supplies in which domestic waste is discharged should contain ABS, although in many instances dilution will lower the concentration below the limits of detection. To illustrate this point, a series of samples from surface supplies in Michigan was examined (Table 4). Samples were taken at approximately weekly intervals during August and September 1960, and analyzed by use of the methylene blue procedure.

TABLE 4

ABS Concentration in Michigan Surface Supplies

Source	Sample Number			
	1	2	3	4
	ABS Concentration—*ppm*			
Cass River				
Frankenmuth	0.0	0.0	0.1	
Clinton River				
Utica	0.5	0.5	0.5	0.6
River Raisin				
Blissfield	0.0	0.1	0.2	0.0
Dundee	0.1	0.0	0.1	0.0
Rouge River				
Rockford	0.0	0.2	0.0	0.0

TABLE 5

Results of Well Survey

Item	Number of Wells
Wells sampled	30
ABS detected	21
Coliform organisms detected	5
Coliform organisms and ABS not detected	9

In regard to ground water, numerous laboratory reports show ABS concentrations ranging up to several parts per million in private wells. No instances of ABS contamination in municipal wells have come to the attention of the Michigan health department. Municipal wells must meet certain enforced requirements of isolation and construction and are not commonly in areas with numerous septic tanks and seepage beds. With time, however, it is possible that ABS may be found in some of these wells.

A survey was conducted by a local Michigan health department in a limited area with individual well and septic tank installations on small lots (Table 5). Wells were 12–30 ft deep. All the samples containing coliform organisms also contained ABS.

ABS occurrence in private wells, particularly in crowded areas, is more common than that in municipal wells. This is true because of the less effective controls on private wells, and because private wells are usually associated with septic tanks that discharge wastes including ABS, which may eventually find its way to the water-bearing formation. In another area,

rapid housing development utilizing individual wells and septic tanks in a relatively shallow sand aquifer overlying an impermeable formation has led to numerous instances of ABS contamination. In one instance, flushing of a toilet resulted in a quantity of foam sufficient to flow over the bowl and onto the bathroom floor.

Instances such as these, coupled with public health and economic considerations, recently caused the Federal Housing Administration to grant a sum of money to the Michigan health department for development of a field test suitable for use by local health authorities as a screening procedure. In conjunction with this test, it is proposed to conduct a survey in selected areas of the state, with about 500 determinations to be made in the field and duplicate samples to be analyzed in the Michigan department laboratory for evaluation of the procedure.

Monthly Water Bond Interest Costs and Sales

A report of the Chief, Basic Data Branch, Div. of Water Supply & Pollution Control, US Public Health Service, Washington, D.C.

Month	1959–60 Net Interest Cost—*per cent*		Total Bond Sales—*$1,000,000*		
	General Obligation Bonds	Revenue Bonds	1959–60	1958–59	1957–58
Dec.	3.83	4.53	18.4	11.5	43.2
Jan.	3.95	3.86	20.5	28.3	35.3
Feb.	4.00	4.48	39.5	62.1	56.7
Mar.	4.12	5.63	15.8	57.0	24.8
Apr.	3.86	4.34	36.7	44.4	40.0
May	3.77	4.28	48.6	105.5	22.7
Jun.	3.77	3.77	110.7	50.3	20.1
Jul.	3.96	3.92	32.4	17.3	39.0
Aug.	3.33	4.02	46.3	25.5	37.7
Sep.	3.53	3.74	15.3	16.6	14.3
Oct.	3.61	3.79	19.0	68.4	60.8
Nov.	3.25	3.80	16.4	36.3	42.5
Total			419.6	523.2	437.0

Synthetic Detergents as a Criterion of Wisconsin Ground Water Pollution

M. Starr Nichols and Elaine Koepp

A paper presented on Sep. 29, 1960, at the Wisconsin Section Meeting, Madison, Wis., by M. Starr Nichols, Emeritus Prof. of San. Chemistry, Univ. of Wisconsin, Madison, Wis., and Elaine Koepp, Bacteriologist, State Laboratory of Hygiene, Madison, Wis.

DURING the past 5 years, increasing numbers of water samples from privately owned shallow wells in Wisconsin have shown frothing when they were agitated prior to bacteriologic analysis. The bacteriologic test, made in accordance with the confirmed coliform test prescribed in *Standard Methods*,[1] sometimes showed the waters to be safe and sometimes unsafe.

In 1958, spot checks on waters from privately owned shallow wells showed detergents to be present in quantities ranging from a trace (0.1 mg/l) to 10 mg/l in 80 of 140 waters tested. Walton, in a recently published JOURNAL article,[2] reviewed the literature on alkyl benzene sulfonate (ABS) contamination of various types of waters, including those from shallow wells in "fringe areas" near cities.

Screening Program and Method

Beginning in January 1959, a screening program was begun on waters from privately owned shallow wells. As the Wisconsin Laboratory of Hygiene at Madison makes annual bacteriologic tests on waters from more than 50,000 publicly owned and privately owned supplies, it was necessary, because of the size of the laboratory staff, to limit the work on detergents to those waters from wells (mostly driven) most likely to be polluted with waste waters. The work was further limited to the detection of anionic detergents, as about 90 per cent of all synthetic detergents used are of the ABS type. The method used was essentially that proposed by Jones,[3] who used an excess of a cationic dye (methylene blue) to bring about a reaction with the anionic sulfonate to form a chloroform-soluble colored (blue) compound. The amount of such color compound formed and extracted by the chloroform was found to be quantitatively proportional to the amount of detergent present in the water. As the work was essentially a screening program, no attempt was made to remove the last trace of detergent from the water examined by repeated extraction. The method consisted of these steps:

1. A 25-ml sample of water to be tested was placed into a 125-ml separatory funnel.

2. Approximately 2–3 ml of 1*N* sulfuric acid was added to the funnel, followed by 10 ml of 0.01 per cent aqueous methylene blue solution and 10 ml of chloroform.

3. The stopper was replaced in the separatory funnel, and the contents were shaken for approximately 1 min.

4. The lower chloroform layer was allowed to separate from the top aqueous layer; then it was drawn off into test tubes of uniform diameter and diluted to 10 ml with chloroform.

5. The color of the chloroform layer was compared with standards prepared and extracted, as prescribed above, from known concentrations of ABS in distilled water. Concentrations less than 1.0 mg/l were considered as trace concentrations, even if there was considerable color present.

Test Results

During the first 6 months of 1959, privately owned shallow well waters were tested for detergents, frothing, and bacteriologic quality. The results of tests made on 2,167 waters are shown in Table 1.

TABLE 1

Frequency and Bacteriologic Quality of Detergent-Containing Waters

Classification of Waters	Total Number	Percentage	Number Unsafe	Percentage Unsafe
All waters tested	2,167	100	277	12.8
Free of detergents	1,471	67.9	136	9.2
Detergents present in trace* amounts to 10 mg/l	696	32.1	141	20.3
Trace* amounts of detergents only	316	14.5	54	17.0
1.0 mg/l detergents	227	10.5	39	17.2
2.0 mg/l detergents	81	3.8	17	20.9
3.0–10 mg/l detergents	72	3.3	31	43.1

* Less than 1.0 mg/l.

Evaluation of Results

The results in Table 1 show that 277 waters were classified unsafe after bacteriologic test. On the other hand, chemical pollution (detergents) was present in 696 of these waters. This finding agrees with experimental results of Stiles, Crohurst, and Thomson [4] at Fort Caswell, N.C. They dosed a trench with human excreta plus the tracing chemical uranin (fluorescein-sodium). Analysis of a series of wells in the direction of ground water flow showed *Esch. coli* to be present 65 ft from the trench; uranin was recovered 115 ft from the trench. In similar experiments with the bored-hole latrine, Caldwell and Parr [5] found that evidence of chemical pollution was apparent at 35 ft after 9 days, whereas evidence of bacterial pollution (*Esch. coli*) was apparent at a distance of 10 ft after 5 weeks. Safe distances between a soil absorption system and a domestic water supply are difficult to determine. Such features as ground water level, water usage, direction of ground water flow, character of mantel deposits (deposits on top of rocks), and subsurface formations from which the supply is taken are some of the factors affecting the location of the two installations.

With regard to bacteriologic classification, Table 1 shows that among those waters free of detergents, there were 136 unsafe waters out of a total of 1,471 waters tested, or a percentage of 9.2. Of 696 waters that contained detergents, 141 waters, or 20.3 per cent, were unsafe—more than double the previous percentage. It

should also be noted that as the quantity of detergents found in these waters increases, the percentage of unsafe waters increases, until the waters with 3–10 mg/l of detergents are 43.1 per cent unsafe, as compared with 9.2 per cent unsafe for waters that showed no detergents—nearly five times as many. Frothing occurred in 103 waters in which detergents were present. Because of the infrequency of frothing, it is not a valid test for detergents.

Sanitary surveys of the conditions surrounding some of the detergent-containing waters were made by W. H. Doyle of the Wisconsin Board of Health who provided the author with survey data. These waters were located in the fringe areas surrounding a Wisconsin city; the areas were without water supply or sewage disposal services from that city. Each home had its own water supply and soil absorption system for waste disposal. Surveys showed poor selection of locations for installations in some instances; in other instances, apparently satisfactory installations existed. Some areas have initiated action to obtain city connections for both water and sewage services to avoid dangers of water pollution.

Recent Biologic Studies

Recent work reported from the Wisconsin Laboratory of Hygiene by Nelson and Hiemstra [6] shows that poliovirus and Coxsackie and ECHO viruses have several of the same characteristics, including inhabitation of the alimentary tract. Nelson and Hiemstra made their isolations of virus from fecal specimens submitted by physicians from localities in Wisconsin. In this study, they made 141 isolations from 826 specimens received, an occurrence of 17.1 per cent. This work is cited as evidence that viruses are a common constituent of sewage containing human excreta. According to Sabin,[7] the diameter of these viruses is 18 mμ * or less, with the exception of the poliovirus, which has a diameter of nearly 30 mμ. For purposes of comparison, the diameters of bacteria, viruses, detergents, and other particles are listed in Table 2.

The table shows that the diameter of such bacteria as the typhoid bacillus (*Salmonella typhosa*) and the coliform group is more than 50 times greater than most of the diameters of the intestinal viruses listed. Soil filtration of sewage will, therefore, remove these bacteria much more readily than the viruses. In other words, the viruses will be able to travel along with the sewage pollution farther than will the coliform group of organisms. The presence of coliform organisms in a water is a good indication of bacterial pollution, but their absence in a water is no assurance of the absence of intestinal viruses. The small size of the detergent molecule and the relatively

TABLE 2

Approximate Diameters of Bacteria, Viruses, Detergents, and Other Particles

Item	Diameter *mμ*
Bacteria (coliform organisms, typhoid)	1,000
Poliomyelitis virus (in feces)	30
ECHO virus (in feces)	18
Coxsackie virus (in feces)	18
Hemoglobin molecule (in blood)	3
ABS molecule (in detergents)	1
Uranin molecule	1
Water molecule	0.4
Hepatitis Virus A (in feces)	*

* Size not known.

$$* \; 1 \text{ m}\mu = \frac{1}{25{,}000{,}000} \text{ in.}$$

high resistance of the ABS molecule to dissolution in water make ABS a comparatively effective indicator of possible intestinal virus contamination of drinking water. At the present time, virus detection in drinking water is not practical as a control measure. The presence of synthetic detergents in drinking water indicates that these "bacteriologically safe" waters may be contaminated with intestinal viruses, and, therefore, may be potentially unsafe because they may transmit intestinal virus infections.

Summary and Conclusions

The presence of coliform organisms is not a satisfactory indication of intestinal virus contamination of drinking water from privately owned shallow wells where a soil absorption system is used for the disposal of domestic sewage. The presence of ABS-type detergents, however, is a satisfactory indication of possible intestinal virus contamination of drinking water from the same wells under the same conditions.

A study showed that anionic-type detergents are present in 32.1 per cent of 2,167 waters from privately owned shallow wells. The data show that as the concentration of detergent increases in these waters, the percentage of bacteriologically unsafe waters becomes larger, until the group of waters with 3–10 mg/l of detergents has nearly five times as many bacteriologically unsafe waters as the group free of detergents. Even when less than 1.0 mg/l of detergents was present, the percentage of bacteriologically unsafe waters was more than doubled. Therefore, according to the data, waters free of detergents are much less apt to be bacteriologically unsafe.

References

1. *Standard Methods for the Examination of Water and Wastewater.* APHA, AWWA & WPCF, New York (11th ed., 1960).
2. WALTON, GRAHAM. Effects of Pollutants in Water Supplies—ABS Contamination. *Jour. AWWA,* 52:1354 (Nov. 1960).
3. JONES, J. H. General Colorimetric Method for the Determination of Small Quantities of Sulfonated or Sulfated Surface-Active Compounds. *J. Assn. Offic. Agr. Chemists,* 28:398 (1945).
4. STILES, C. W.; CROHURST, H. C.; & THOMSON, G. E. Experimental Bacterial and Chemical Pollution of Wells Via Ground Water, and the Factors Involved. *Hyg. Lab. Bul.* 147, US Public Health Service, Washington, D.C. (1927).
5. CALDWELL, E. L. & PARR, L. W. Ground Water Pollution and the Bored-Hole Latrine. *J. Infectious Diseases,* 61:148 (1937).
6. NELSON, D. B. & HIEMSTRA, HAZEL. Enterovirus Isolations and Studies in the State of Wisconsin: 1957 and 1958. *Wisconsin Med. J.,* 59:311 (1960).
7. SABIN, A. B. A New Group of Respiratory and Enteric Viruses Formerly Classified as ECHO-Type 10. *Science,* 130:1387 (1959).

Rapid Disinfection of Water With High Concentrations of Hypochlorite

Earl D. Christian, Mary F. Barada, and Charles E. Renn

A contribution to the Journal by Earl D. Christian, Dist. San. Engr., State Dept. of Health, Little Rock, Ark.; and Mary F. Barada, Research Asst., and Charles E. Renn, Prof. of San. Eng., both of the Dept. of San. Eng. & Water Resources, Johns Hopkins Univ., Baltimore, Md. The senior author carried out the engineering phases of the study, and the data presented are part of the senior author's thesis in partial fulfillment of the requirements for the degree of Master of Science in Engineering at Johns Hopkins Univ.

THE water supply and sanitary engineering professions have accepted relatively low chlorine concentrations and long holding times for disinfecting potable waters. These limits are generally congenial with other requirements. Abundant basic data are now available on the relationships of temperature, pH, chlorine concentrations and equilibria, and moderating materials in water, to disinfection rates for conservative design. Also available is a large reservoir of special information from plant and other practice.

There are special conditions for which comparatively high concentrations of chlorine are used for disinfecting potable water. These include a variety of emergency and field treatment steps by hyperchlorination, with or without dechlorination, and individual home and institutional chlorination-dechlorination treatment processes in which as much as 50 ppm hypochlorite is applied for intervals of 1 min or less.

The potential effectiveness of such high chlorine concentrations cannot be satisfactorily assessed by an extension of the experience with low chlorine concentrations and long contact times. It is reasonable to assume, however, that disinfection with high concentrations of chlorine will be more rapid than disinfection with low concentrations under the same conditions. But regulatory agencies have been understandably conservative in accepting unconventionally short contact times, especially for systems in which all active residuals are removed during the dechlorination step.

Procedure and Equipment

Until the developments made in this study were put to use, it was impossible to determine directly the rates at which very active disinfecting agents, such as high concentrations of chlorine, operate. The manipulations in the laboratory measurement of bactericidal rates set the shortest time interval that may be examined. With high chlorine concentrations, under representative conditions, the entire bacterial test population is destroyed before a satis-

factory sample can be withdrawn. A skilled team of bacteriologists may perform, in 12–15 sec, the necessary steps of: (1) adding the test bacteria to the sterile test water, (2) adding the disinfectant in controlled concentrations, (3) mixing the disinfectant through the volume of the test suspension, (4) adding a neutralizing agent to stop disinfecting action, and (5) mixing the neutralizing agent through the test system. Within this interval, free available chlorine in a 5–10-ppm concentration range will reduce test concentrations of coliform organisms to unmeasurably low levels.

The five steps listed above have been mechanized so that it is possible to measure bacterial kills by high chlorine concentrations over intervals as short as 0.1 sec. The equipment and process are also readily adapted for the study of other disinfecting systems, enzyme reaction rates, and a variety of biochemical and physiologic processes involving two or more reacting materials.

The process consists of the following steps:

1. A stock suspension of test bacteria is run, at a controlled rate, through a tube of fixed and known volume.
2. The hypochlorite solution mixes with the bacterial suspension as it enters the calibrated flow tube.
3. Disinfection reactions occur during flow residence within the tube.
4. The disinfected suspension discharges into a collection vessel containing dilution water and a large excess of sodium thiosulfate.
5. Samples taken at the beginning and end of the flow-contact system reflect chemical and bacteriologic changes.

The practical details of these steps can be understood by an examination of Fig. 1. At the start, the 30-gal insulated stainless-steel test water supply tank is filled with filtered water from the laboratory supply. The tank supply is checked for free and combined chlorine residuals, and a small excess of sodium sulfite is added. The recirculating refrigeration temperature control is started, and the system is allowed to come to the desired temperature overnight. In the morning, the temperature and chlorine residual are checked, and any desired adjustments in the pH of the test water supply are made. The tests reported here were made at low temperatures of 3.5–4.0°C, within the pH range 7.0–8.2.

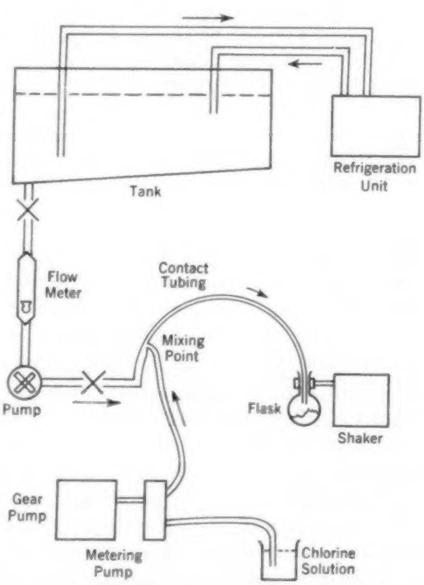


Fig. 1. Schematic Flow Diagram of Experimental Equipment

This automated process is convenient for studies of disinfection rates. The two cross marks in the diagram represent control values.

The bacterial test population is added and mixed through the storage tank by the recirculating pump. In this study, the bacterial suspension was prepared by washing the growth from a 20-hr slant of *Esch. coli* * and suspending it in a saline solution, and roughly estimated by dilution to calibrated turbidity values.

The various flows in the contact system are then adjusted to secure the desired contact time and initial chlorine concentration levels. These variables can be controlled in several ways. The contact time is determined by dividing the volume of the contact tube by the flow rate through the tube. Flexible tubing † of varying lengths and diameters was used, and estimated volumes were checked by weighing the water contained in the test lines. Flow rates were measured directly. The flow meter shown in Fig. 1 provides a convenient means for making quick settings of the adjusted values.

Hypochlorite stock solutions, prepared by diluting commercial sodium hypochlorite, are pumped through a hypodermic needle inserted in the venturi constriction at the entrance of the contact tube. The flow rates of the disinfectant are controlled by a variable-speed transmission driving a rayon spinning-gear pump.‡ This provides pulse-free metered flow.

To determine initial steady conditions, several gallons of bacterial suspension are run through the system and adjusted for desired initial and terminal chlorine residuals. (The laboratory water, which normally bears a free available chlorine residual, showed negligible chlorine demand over the short test intervals used.) Flow rates are also rechecked.

A series of sterile 500-ml Florence flasks containing 10 ml of normal sodium thiosulfate are locked into the arms of a wrist-action shaker § and the shaking amplitude adjusted to give violent stirring. The general switch is closed and the system activated. After an interval of a few minutes, during which time the system is flushed and the motors brought to steady speeds, the collection signal is given, and the chlorinated bacterial suspension is directed into the dechlorinating collection flasks.

Bacterial counts of surviving bacteria are made by the membrane filter technique, with the use of Chesney's terminal endo technique. This technique proved eminently satisfactory for the large number of comparative determinations imposed upon the bacteriologist in this work.

Advantageous Features

Several features of this automated process make the system uniquely convenient for studies of disinfection rates:

1. The large volume of refrigerated bacterial suspension held in an insulated storage system permits many tests with a single bacterial population.

2. The pH and temperature of the large volume of test suspension remain relatively stable over a long working period.

3. The contact period and chlorine dosage may be readjusted and approximated in a few minutes and the effective values measured in 10–15 min. A favorable working day produces a relatively large amount of data—the limit

* US Food & Drug test strain, supplied by Robert A. Taft Sanitary Engineering Center, Environmental Health Division, Cincinnati, Ohio.

† Made of Tygon, a product of US Stoneware Co., Tallmadge, Ohio.

‡ Made by Zenith Products, West Newton, Mass.

§ Made by Burrell Corp., Pittsburgh, Pa.

is set by the volume of bacteriologic work and time required for preparing accessory bacteriologic materials.

The system used has chlorine concentrations and contact times anticipated in modern chlorination-dechlorination disinfection of individual household water supplies and small community water systems.

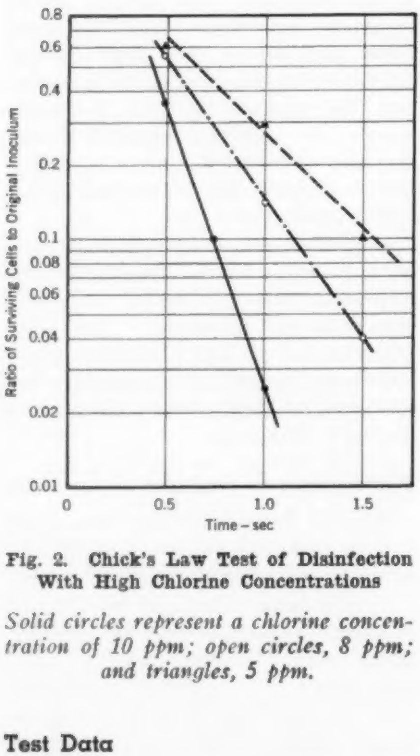


Fig. 2. Chick's Law Test of Disinfection With High Chlorine Concentrations

Solid circles represent a chlorine concentration of 10 ppm; open circles, 8 ppm; and triangles, 5 ppm.

Test Data

Eight complete groups of tests were made under these conditions: temperature range, 3.5–4.0°C; pH range, 7.8–8.2; free available chlorine (flash orthotolidine), 5.0, 8.0, and 10.0 ppm; *Esch. coli* density, 25,000–250,000 per 100 ml; and contact times, 0.2, 0.5, 0.7, 1.0, 1.5, and 5.0 sec.

A summary of the data from the eight tests is plotted in Fig. 2. It may be seen that the rate of kill or disinfection approximates the relationships anticipated by Chick's Law: at fixed concentrations of disinfectant, a constant fraction of the initial test population is killed in each time interval. The time required to kill a selected percentage of the bacterial population is inversely proportional to the free available chlorine concentration. These findings are all consistent with the relationships found earlier by other investigators working with low concentrations of chlorine.

Evaluation of Technique

The practical implications of these data are most useful in evaluating the potentialities of water disinfection by high chlorine residuals. High free chlorine residuals are easily secured in household water purification systems, but it is more difficult to provide conventional, long holding times. Effective contact intervals of seconds are often available in household lines themselves. A 10-gpm flow in a $\frac{3}{4}$-in. ID pipe represents a travel distance of only 7.5 ft in 1 sec. A flow contact distance of about 11 ft at this rate in waters with 5.0 ppm free available chlorine should effect 90 per cent reduction in the bacterial concentration of the water, and double this flow distance should reduce the population to 1 per cent or less of the initial concentration. At the higher concentration of 10 ppm free available chlorine, 99 per cent of the bacteria will be killed in 11 ft of travel, and 99.9 per cent in 22 ft.

In the most common household water disinfection systems, chlorine is added to the water immediately before it is pumped into the pressure tank.

The possibility that water may "mix through" or mix imperfectly in the tank during certain regimes of pumping and draught is recognized, and various controls by interlocking switches and by tank baffling have been used. It can be seen that the household piping system beyond the tank may also provide supplemental chlorination-contact time to insure disinfection.

At higher temperatures and lower pH values in the water, the rates of disinfection by comparable concentrations of free available chlorine increase, so that the values derived from experience with cold, alkaline waters tend to be conservative. On the other hand, it may be expected that very alkaline waters, with pH values greater than 8.2, will be less rapidly disinfected. The reduction should be comparable to the decrease in undissociated hypochlorous acid in the system at higher pH values.

Other factors that moderate the effectiveness of chlorine disinfection must be considered in practical evaluations. The studies reported here were carried out with filtered waters, free of plankton and coarse suspended materials. The short-term chlorine demand of the test waters was completely satisfied, and the concentrations of addition products formed were insignificant. These conditions are readily met in most small household and individual supplies by clarification or filtration and the addition of chlorine supplements to yield terminal free chlorine activities. The point is that these requirements should not be neglected in small supply disinfection design.

Acknowledgments

Funds and major equipment items for these studies were provided by Everpure, Inc. and the National Water Purification Foundation, Chicago, Ill. The equipment and techniques used in these studies were developed in the laboratories of the Department of Sanitary Engineering and Water Resources at Johns Hopkins University, Baltimore, Md.

Trends in Water Supply Legislation and Litigation

Edward F. Taylor

A contribution to the Journal by Edward F. Taylor, Taylor & Smith, Attorneys, and City Attorney, Redlands, Calif. This paper originated as part of a report presented to the annual convention of the National Institute of Municipal Law Officers, Pittsburgh, Pa., by the author, as chairman of the Committee on Municipal Water Problems.

BOLD federal claims to water in the West, many of which have been supported by court decisions, have been met with vigorous protests from municipal leaders, the states, and Congress itself. Although other more obvious points of constitutional tension have dominated the headlines, the conflict over water poses fundamental issues of states' rights. The alarm of the few owners of water rights first confronted with demands of the United States has spread across the nation.

The year battle lines were drawn was 1955. Until then, the federal government complied with state laws governing the appropriation and use of water resources. Congress followed this policy when it authorized the construction of water projects in the West. As a result, the states, particularly the seventeen Western states, proceeded to develop water resources with the assurance that local laws provided the sole basis for the maintenance of systems of water rights.

In 1955, however, the momentous Pelton Dam decision was handed down.[1] In this case, the United States insisted that when it withdraws or reserves public lands, it is not subject to state laws. Although the Desert Land Acts, enacted before the turn of the century, specifically gave federal recognition and protection to rights which are recognized by "local customs, laws, and the decisions of courts," the US Supreme Court upheld the federal government's new position in the Pelton Dam case.

A pattern of supremacy of federal claims—ominous from the states' point of view—quickly developed in two cases. The US Supreme Court, reversing a decision by California's highest tribunal in the Ivanhoe case, declared that the United States was not required to comply with state law in the operation of a reclamation project under contracts with public agencies of the state. California's petition for rehearing and clarification by the US Supreme Court states that the Ivanhoe decisions "represent an unjustifiable extension of federal power in disparagement of both the legislative and judicial authority of the states." [2]

Then, the Navy refused to comply with Nevada laws requiring applications for its appropriations of water for Hawthorne Ammunition Base, and Nevada filed an action for declaratory

relief. The US district judge ordered dismissal of the complaint with this terse explantion: "[T]here is no mandate in constitutional, statutory, or decisional law that compels the federal government to bend its knee to this type of state law and regulations." [3]

The most recent threat? The US Department of Justice claims the federal government owns all the water in California under a 112-year-old treaty with Mexico. This demand was made when the city of Fresno sued to establish its right to used water from the San Joaquin River.

Opposition to Federal Claims

The actions of the federal government and court rulings have awakened many leaders to the urgency of preserving state water rights, and not all federal courts have supported the federal position. In a comprehensive pretrial opinion in the Fallbrook case, federal Judge James M. Carter held the rights of the United States to waters of the Santa Margarita River for use on the Marine base at Camp Pendleton, Calif., will be determined by the same rules applicable to any other state water law. The judge said there is no special federal right to take water for the military establishment by reason of sovereignty or national defense.[4]

The 86th Congress held comprehensive hearings on several proposed states' rights measures. Senator Joseph C. O'Mahoney warned that a defeat of the states' position will leave many water users only "a defeasible right of use at the sufferance of the federal government." In the West, states have granted a quarter of a million water rights, whose orderly administration relies on local authorities and not federal controls.

"If a federal or a federally licensed project can be built on a stream without a date of priority and a limitation of use in its proper priority relationships to nonfederal rights which rely on the laws of the states, then those nonfederal properties are in jeopardy," O'Mahoney said.

A joint resolution of the Tennessee legislature called upon the Congress and the President to preserve individual water rights, prevent federal usurpation of those rights, and reaffirm the concept that water rights are property rights which cannot be taken away without due process of law.

The states' rights issue dominated the Conference of Western State Engineers, which reviewed the sovereign right of states to regulate and control the waters within their boundaries. A member of the conference, M. G. Walker, supervisor of the Washington State Division of Water Resources, addressed the following appeal to the water problems committee of the National Institute of Municipal Law Officers (NIMLO):

> We believe that your committee could do a great service, not only to your municipalities but to your respective state[s], if you were to study the effect of some of these recent court decisions and to review this legislation toward selecting and supporting bills which you feel can come more closely to correcting a bad situation.

The Irrigation District's Association of California, meeting in its May 1960 convention, supported the "traditional policy of state ownership and control in water and water rights." The association demanded that the United States be required to conform to and observe state procedures and rights in water matters and urged congressional action

to negate the right of federal agents and representatives to take and acquire property, particularly water rights, without eminent-domain proceedings.

State-Federal Rights Litigation

Water rights disputes often erupt into litigation, and municipalities, as a principal competitor for additional water, make regular visits to court. A summary of the major lawsuits in progress or recently decided is presented below.

In *Arizona* v. *California,*[5] Arizona cast a great cloud over water rights essential to 7,000,000 Southern Califorians in 86 municipal units of the sprawling Metropolitan Water District. The 380-page decision by Special Master Simon H. Rifkind cut Caliornia's right by nearly a 1,000,000 acre-ft and granted Arizona's claim to 2,800,000 acre-ft. Rifkind's report now goes to the US Supreme Court for final approval. If adopted, the decree will aggravate the state's critical water shortage.

"The report points up the need for immediate development of other water resources," Governor Brown of California said. "I urge anew that voters approve the 1.75 billion dollar bond issue in November.* We need to export surplus northern California water to the south," he added.

The legal effect of the report, according to Attorney General Stanley Mosk, is that it "sweeps aside in one motion 600 years of Western water law." Rifkind rejected California's contention that traditional principles of water law apply and allowed Arizona's claims under the Boulder Canyon Project Act, in which Congress authorized the construction of Hoover Dam.

The decision deprives California of water that was expected to serve more than 5,000,000 people. The populous Los Angeles, San Diego, and Riverside–San Bernardino metropolitan areas are hardest hit.

The suit involves more people, more water, and greater property values than any other water case on record. Half the people of California are directly involved in the outcome. More than $500,000,000 has been invested directly in the development and utilization of the waters of the Colorado River. During the course of the trial, 106 witnesses, most of them experts in their fields, took part in the case. Nearly 50 attorneys were involved. The contending parties introduced 3,950 exhibits and there were 22,593 pages of transcript.

The state, joined by the other defendants, has asked for a rehearing before Rifkind. The last of the "long suit"—so called because it lasted 5 years and stems from disputes which arose years ago—has yet to be heard. The controversy has been carried on to the US Supreme Court for a legal showdown.

Fresno's complaint in intervention set the stage for Judge Peirson M. Hall's momentous decision, in *Rank* v. *Krug,*[6] that the United States is subject to California water law. No lawsuit has ever brought a federal–municipal water rights conflict into sharper focus. The city obtained a declaratory judgment that its rights for domestic and municipal purposes are superior to any right of the United States to divert water beyond the watershed or county of origin. The

* The issue was approved.

decision has been challenged in an appeal pending before the 9th US Circuit Court of Appeals. The case involves the San Joaquin River and the Friant Dam constructed on the river by the Bureau of Reclamation.

As a municipality furnishing water for domestic and municipal uses, Fresno was held to have a preferred position under the California Constitution and statutes above both the United States and several irrigation districts. The court declared that this is so by the terms of the statutes on watershed and county of origin and by the Statutes of California, which declare use of water for domestic and municipal purposes to be the most proper use.

Water owners along the river contended that the federal government's operation of Friant Dam as part of the Central Valley Plan unlawfully reduced the full flows of the San Joaquin River. The case arose from refusal of the federal government to deliver water through Friant Dam to prior users on the San Joaquin River. To justify its denial of compensation to many claimants for their loss and its transfer of water to the southern end of the river valley for a new class of water user under recent project contracts, the federal government claimed the entire flow of the San Joaquin River by exercise of its power of eminent domain. The United States based its right to water released from Friant upon the sole discretion of the federal officials in charge. The case illustrates the federal theory that a paramount national proprietary interest gives it legal justification for limiting private rights.

The California Water Rights Board had decided the application of the United States, the city of Fresno, and the Fresno Irrigation District to appropriate surplus water of the San Joaquin River. The board held that the municipal preference contained in the Water Code, the County of Origin Act, and the Watershed Protection Law did not support Fresno's opposition to the federal applications. Fresno then instituted court proceedings to claim municipal preference and the protection of the County of Origin Act and Watershed Protection Law.

In *City of Seattle* v. *State,*[7] Seattle condemned certain state school and capitol building lands situated outside the city for a reservoir site on the Tolt River. The judgment of the superior court in favor of the city was affirmed by the Washington supreme court. It concluded that Washington law authorized the city to take state-owned lands outside of its corporate limits and found the lands had not previously been dedicated to public use. The decision expedites Seattle's major water supply development on the Tolt River.

In *Orange County Water District* v. *Riverside and others,*[8] a trial court judgment in 1959 drastically limited four California cities' water production from the Santa Ana River. In 1960 the complexion of the case changed when Riverside, Redlands, San Bernardino, and Colton were successful with several points they presented on appeal.

Their water rights were increased from 10 to 70 per cent each and the injunction was stayed for a 3-year period after judgment becomes final on appeal. This provision allows the cities time to obtain a supplementary supply of water, since they will not be required immediately to cut back their production to the prescriptive rights as recomputed by the appeal court. But

the right of the cities to receive water from any other source in the watershed—denied by the trial judge—was upheld on appeal. The higher court held that the state constitution authorizes the cities to acquire vested property interests such as shares of stock in mutual water companies. This ruling, removing the trial judge's blanket prohibition against receiving water, was hailed by the cities as a major victory. If affirmed, the judgment would have curtailed the cities' production from municipal facilities and shut them off from any other source. Since the ruling, active programs of water rights acquisition, especially mutual stock, have been launched by the cities. Redlands and Riverside, which have been snapping up stock for some time, enjoy a head start.

It is clear from the decision that the appeal court rejected the district's attempt to clap a lid on the entire basin while confining the suit to a few cities. The major market remaining for many mutuals in a time of rapid transition from agriculture, largely citrus, is the cities. It was the aim of the district to force retirement of mutual stock, so that the available water would have no place to go but downstream to the district.

Orange County filed a class action on behalf of all overlying owners in the district to take advantage of their paramount rights. The cities are deemed appropriators, with inferior rights, under California law. Their contention that a city operates as an agent exercising the superior rights of its inhabitants was heard with interest. So was the argument that the district, having no property rights of its own and showing no title in anyone it purported to represent, failed to state a cause of action. Neither theory was adopted.

Another basic question is causation. The trial judge's finding that taking 1 acre-ft of water upstream reduced the supply by the same amount 50 mi downstream was not accepted by the district court. Its opinion cites a number of other consumptive uses of water, such as evaporation and transpiration.

Illinois Lake Diversion

By decree of the US Supreme Court in 1930, Illinois and the Sanitary District of Chicago (formerly the Metropolitan Sanitary District of Greater Chicago) were required to reduce the average rate of withdrawals from Lake Michigan to 1,500 cfs in addition to domestic pumpage by the end of 1938. In compliance with that decree, the sanitary district also has spent more than $300,000,000 in providing treatment plants and other facilities.

In the past several sessions of Congress, a bill has been presented to authorize the Sanitary District of Chicago to increase the diversion rate by an additional 1,000 cfs for a test period of 2 years. Tests would be made by the US Army Corps of Engineers and USPHS to determine the effect of this increase on the Great Lakes and the Illinois Waterway. On two occasions, the bill has been passed by Congress, only to be vetoed by the President because of objections raised by Canada. In the 86th Congress, it was passed by the House and approved by the Senate Public Works Committee, but, after considerable debate the bill was referred to the Senate Foreign Relations Committee ostensibly to consider the objections of Canada and its alleged impact on relations with that

country. As a result, the bill died without action by the Senate.

This year, the Great Lakes states, Wisconsin, Minnesota, Ohio, Pennsylvania, Michigan, and New York, filed an application to reexamine the decree; and the court referred the case to a special master, Albert Branson Maris, Senior United States Circuit Judge for the Third Circuit. He will also hear the separate complaint filed by Illinois against the same six states for a declaratory judgment and injunction on behalf of the Elmhurst–Villa Park–Lombard Water Commission. This newly formed agency was created by the Illinois legislature for the purpose of supplying water from Lake Michigan to Elmhurst, Villa Park, and Lombard, whose deep wells have been exhausted. The three communities desperately need more water. They claim the only practical source is Lake Michigan and formed the commission to get it. When the commission sought to finance the project by revenue bonds, the Great Lakes states threatened an injunction. On the commission's behalf, the attorney general of Illinois brought the action in the US Supreme Court.

A new development in these original cases is that the six states which filed the amended application to open the 1930 decree are asking the court to require the treatment of effluent before it is returned to Lake Michigan. The larger part of the domestic pumpage is used by Chicago and its environs. The deposit of untreated effluent into the supply could create a serious threat to public health in these communities.

Kansas Litigation

There has been prolonged litigation in both state and federal courts over Wichita's practice of tapping an underground water supply located 20 mi way. This source is the so-called equus beds located primarily in Harvey County, Kan. These beds form an underground lake covering hundreds of square miles. The complaint accuses Wichita of lowering the water table and damaging crops, trees, and water supplies of farmers.

The water has been taken in accordance with the Kansas Water Act and by easements and licenses from landowners. The city of Newton has been interested in the effect of the suit on its water allocations from the state water resources engineer. The large number of suits on file has not deterred Wichita from continuing to take water from the area.

Ivanhoe Irrigation District Cases

The California supreme court devoted a full day to a rehearing of four Ivanhoe Irrigation District cases, which involve contracts between the Bureau of Reclamation, several water districts, and individuals. The rehearing was required after the court's earlier decision was unanimously reversed by the US Supreme Court, which upheld the legality of the contracts and said that irrigation districts, as agencies of the state, can execute contracts with acreage limitation provisions.

The complicated cases began in 1950, when Courtney McCracken, a Woodlake farmer, filed action against the Ivanhoe Irrigation District [2] to determine whether the water service contracts he executed with the district required him to comply with the excessland provisions of the Federal Reclamation Law. The decision turns on questions of whether federal agencies must follow state law, the authority of

state public agencies to comply with the contract provisions, and their constitutionality under the due-process and equal-protection clauses.

The California supreme court's theory that the United States had assumed the same trust obligations and responsibilities borne by the state also was upset. The opinion considered the acquisition of water rights and the operation of a federal reclamation project to be two different things. The United States is required to comply with state law in the construction and operation of a reclamation project only when it is necessary to acquire water rights. Congress did not intend to override the long established national policy embodied in the excess-land provisions, the court said.

Two years ago, the Texas law authorizing grants of permits to cities to impound water was amended to provide that administrative decisions of the water board are appealable to the district court, or a court exercising original jurisdiction in civil cases involving unlimited amounts, and that such trial would be a *de novo* trial. The Texas supreme court held that the portion of the statute providing for a *de novo* trial was unconstitutional. Under the state constitution, the decision of the State Board of Water Engineers is reviewable only under the substantial-evidence rule, the court said.

Los Angeles Pueblo Rights

Los Angeles v. *San Fernando, Glendale, Burbank, and others* [9]; the major lawsuit over Los Angeles' pueblo water rights—a unique facet of California water law—is heading for court. The 214 defendants named in the Los Angeles complaint have been narrowed to a handful of parties, including the cities of San Ferenando, Glendale, and Burbank. The action to settle title alleges a prior and paramount right in the plaintiff as the successor of the pueblo of Los Angeles to surface and subsurface waters of the San Fernando Valley drainage area on the basis that all of such waters are waters of the Los Angeles River. An injunction is sought against withdrawals of water from the drainage area.

The plaintiff claims that a United States city that can be shown to have succeeded a Spanish or Mexican pueblo has a prior and paramount right to the water naturally flowing through the original pueblo for the use of the inhabitants and that the right grows with new inhabitants and expanding city limits, including lands not part of the original pueblo. This explains Los Angeles' claim to a right "coextensive with the increasing boundaries and population and the increasing needs for water of said city and of its inhabitants"—a large order, indeed, for one of the nation's fastest-growing metropolitan areas.

After six pretrial sessions, the parties settled objections to interrogatories. The court made an order allowing the parties 6 months within which to answer them. The seventh pretrial session was scheduled for February 1960, when answers to the interrogatories were to be filed. The defendants were successful in their motion to have the physical facts investigated by the California Water Rights Board. The court, before making the order, went into the matter quite thoroughly as to the time that would be required and the estimated cost. The board estimated that it would take 2 years and would cost $250,000. Pre-

liminary reports were to be received from the board in June 1960, and the trial is expected to open in the spring of 1961.

Wisconsin Water Permit Dispute

The Wisconsin Public Service Commission administers a statute which requires permits before water can be taken from any stream for agriculture or irrigation. Recently, municipalities have appeared before the commission to oppose taking of water for purposes of irrigation. The cities claim this water is needed to dilute sewage effluent. Generally, each case is handled on its merits, and permits for irrigation are issued if it appears that there is no injury to public rights or lower riparians. The construction given the statute by the commission has been rejected by a judge of the Dane County circuit court. For that reason, the law is not settled. When riparians tap a stream for irrigation, the problem of the rights of other users, including municipalities, is resolved by cases before the commission and the courts.

California District Disputes

The protracted controversy between Monterey County and San Luis Obispo County in California over waters of San Antonio and Nacimiento Rivers has been settled. The California Water Rights Board had held lengthy hearings to consider the development programs of the two counties and indicated that unless some compromise settlement was reached, a ruling would follow.

The basic terms of the agreement are that Monterey County is to guarantee San Luis Obispo County 17,500 acre-ft of water per year, when the agreement takes full effect, and San Luis Obispo County agrees to pay for the water on an acre-ft price based on the cost of construction of the San Antonio dam and reservoir.

San Luis Rey Water Conservation District brought suit on behalf of all the overlying land owners within its boundaries to enjoin Carlsbad from continuing to export water from the Mission basin in Southern California.[10]

The complaint alleged that no surplus exists, and there is insufficient water for reasonable and beneficial use by overlying owners. Carlsbad admits physical overdraft, but contends that it owns a prescriptive right—analogous to adverse title—to extract and export water from the basin.

In a memorandum opinion, the court held that both plaintiff and defendant have established mutually prescriptive rights. Each is entitled to extract water in quantities allocated on the basis of past production and limited by safe yield.

The district resisted the claim of adverse title, on the theory that overlying owners had no notice their rights were being invaded. But the knowledge necessary to show adverse possession was implied by the trial judge from evidence that studies had been published by governmental agencies and water rights litigation in the area gave the defendants knowledge of overdraft conditions.

San Gabriel River Suit

Rights to water from one of California's major watersheds were the subject of litigation in 1960.[11] Users of water from the San Gabriel River, which drains more than 600 sq mi of urban and agricultural land, were sued by the cities of Long Beach and Compton and the Central Basin Municipal

Water District. The 25 defendants include the nine cities of Alhambra, Arcadia, Azusa, Covina, El Monte, Glendora, Monrovia, Monterey Park, and South Pasadena.

Basically, the action was brought by downstream claimants, of which Long Beach is nearest the ocean. These parties contend that there is an overdraft on the underground supply, and that water levels are continuing to drop.

As members of the Metropolitan Municipal Water District, the plaintiffs are acquiring water for domestic demands and spreading to replenish the basin. The water utilities and cities upstream are not members of the Metropolitan Municipal Water District. They are accused of using more than their share of the available water of the San Gabriel River, to the detriment of the downstream plaintiffs.

The complaint alleges that beneath the San Gabriel Valley area and the Central Basin area there exist natural reservoirs known as ground water basins; that the water in these basins comes from precipitation within the watershed; that the only substantial supply of ground water to the lower basin is surface and subsurface flow from the San Gabriel Valley area and that the flow of the river constitutes a common water supply for both basins.

It is further alleged that Long Beach, Compton, and the district own water rights in the common water supply, use large quantities of water for the benefit of their residents, and have expended great sums of money to develop water facilities. They allege that the total replenishment has been substantially less than the total withdrawals and that an overdraft exists.

The complaint also states that there is no surplus for appropriation, the water supply in the lower basin has continued to diminish, and the defendants are extracting increasing quantities of water and causing irreparable damage to the plaintiffs. They also contend that the hydrostatic pressure in the Central Basin area will diminish and permit the intrusion of salt water unless the overdraft is stopped.

The court is asked to restrain interference with the replenishment of the Central Basin area, to require the defendants to set forth the nature and extent of their claims, and to fix their rights.

Service Expansion and Main Extensions

The Ohio constitution provides that a public utility may not supply water outside of the city in amounts exceeding 50 per cent of the total supply within the city. The Ohio supreme court held, in *State* ex rel. v. *Hance*,[12] that the delivery of the utility product within the corporate limits for redelivery outside by the city is unconstitutional where the 50 per cent limitation is exceeded in some of the larger metropolitan areas of the state. It has been the practice to deliver and meter water within the corporate limits of the city selling the water, in order to avoid this constitutional limitation. The court now says that this can no longer be done legally.

A franchise to put water mains in streets and alleys was involved in *Township of Lansing* v. *City of Lansing*.[13] A metropolitan district's charter embraced a township which had a previously established water system under a lawful franchise for use of its own public streets. The charter did not refer to the franchise or power to use streets and alleys. The question

is whether the charter constituted a grant of a franchise to the metropolitan district to use the streets and alleys in the area where the plaintiff township had previously established the water system. The state supreme court held that it did not. The Michigan state constitution provides that no person operating a public utility shall have the right to the use of the highways, streets, alleys or other public places of any city, village, or township without its consent.

In *Woodside Homes, Inc.,* v. *Morristown* (*N.J.*)[14] the city had purchased all the assets and franchise of a privately owned water utility supplying water to the inhabitants of municipalities outside the borders of Morristown. The question involved was whether there was an absolute obligation on the part of Morristown to extend water mains. The court applied the law regarding privately owned utilities, because Morristown had purchased a privately owned utility. It held there was no absolute duty to extend mains unless the New Jersey Public Utility Commission held a public hearing in accordance with the public utility law. The commission must determine whether there is necessity for the main extension and a reasonable opportunity to recover the investment. This case was interesting also because the court permitted the utility to treat large-scale developers of land differently than individual consumers.

Belleville, N.J., built a water system and paid for it by general assessment and taxation rather than local assessment. The facility served the entire town with the exception of one area which had been all farm land. This area was subdivided, and Belleville attempted to levy the entire cost of servicing the area and extending water mains to it by local assessment against the owners of the abutting property. While holding that the power to do so existed, the court set aside the ordinance imposing the local assessment on the ground that the power had been unreasonably exercised.[15] The court found every main in the town had been financed by general assessment and taxation, and that the water utility was being operated at a substantial profit.

The New Jersey appellate division indicated, in *Ecloss Co., Inc.,* v. *Parsippany–Troy Hills,*[16] that a municipality's liability to supply available water at reasonable rates is absolute. The trend, at least in New Jersey, is to treat a municipality operating its own water system much as a privately owned public utility, and as it has a monopoly on water, it is required to extend mains at its own expense so long as the hardship of doing so is not great.

After the Woodside Homes case, a property owner tried to force the New Jersey Public Utilities Commission to require either the municipality or the West Keansburg Water Co. to extend mains. The court held that a municipally owned water utility which had been purchased from a privately owned utility after 1931 was subject to commission regulations as to rates and extensions. It, however, refused to require the municipality to extend the water in this case, because water was available to the property owners from a privately owned water utility.[17]

In *California Water and Telephone Co.* v. *Public Utilities Commission,*[18] the issue was whether a water utility's granting of service to two houses on a 1,146-acre ranch and its signing of private agreements with a developer to extend mains and services under

specified conditions to the ranch land constituted a public dedication to the entire tract as subsequently subdivided.

The California Public Utilities Commission took the position that the water utility had dedicated its services to the entire territory and, therefore, could be ordered to re-execute a water contract as modified by the commission. The court held that the utility could limit its dedication to a territory and that the dedication of property is not presumed without evidence of unequivocal intention on the part of the owner. The court further held that the utility had not dedicated its service to the entire area and that the commission could not compel it to extend its mains into a proposed residential community to be created by subdivision in a nondedicated territory on terms other than those agreed to by the utility.

In a Texas case,[19] it was held that a city could annex and provide water and sewerage to an area within a water district which was unimproved and was not served by the district.

Taxation and Assessment Cases

In *Bacon* v. *Kent-Ottawa Metropolitan Water Authority,*[20] the authority tried to avoid the effect of a constitutional tax limitation. The Michigan constitution contains a provision that limits the total taxes that may be levied against real property to 15 mills per year, unless this amount is increased by vote of the people concerned, but excepts municipal corporations from this requirement. The defendant water authority had been incorporated under a recently enacted state statute which referred to water authorities organized pursuant to its provisions as "municipal corporations." The water authority argued that it was within the exception contained in the constitutional provision, and therefore was not subject to the 15-mill limitation, as the statute purported to give it unlimited taxing authority. The Michigan Supreme Court rejected this argument, holding that the meaning of the term "municipal corporation," as used in the constitution, was limited to those entities which by custom, usage, and judicial decision were regarded as municipal corporations at the time of the enactment of the provision in 1932.

In *City of Los Angeles* v. *County of Inyo* (1959),[21] the issue was the validity of the county's assessment of the water rights owned by the city, which were formerly appurtenant to three residential lots. The court held that the assessments were excessive, discriminatory, and invalid. The court based its decision on the fact that the county assessor treated the water rights as having escaped assessment but did not make a proper entry on the tax roll and that the three lots, including the separately assessed water rights, were assessed at nearly three times the assessment of any other lots.

In *Department of Highways of Pennsylvania* v. *Pennsylvania Public Utility Commission* (1959),[22] the issue was the sharing of costs between Pennsylvania and a political subdivision in connection with the relocation of water lines necessitated by the construction of a state highway. The intermediate appellate court in the state upheld the action of the Pennsylvania Public Utility Commission in allocating the bulk of the relocation costs against the state.

The state had argued that the entire costs should be paid by the municipality, on the ground that it was financially able to do so. The court rejected this position and decided the case on the basis of the actual benefits accruing

to the municipality from the relocation of the water lines.

Trends in Statutory Law

There no longer seems to be a rush to overhaul existing water rights law. To be sure, half the states have enacted comprehensive laws affecting the use of water resources or have set up water study commissions to chart a future course. Furthermore, there remain grave doubts that common-law doctrines, principally in the eastern states, are suited to present conditions. Despite the general recognition that the riparian rights doctrine, which vests superior water rights in owners of ribbons of land abutting on bodies of water, is archaic, no state moved to the prior-appropriation doctrine or a system of permits during 1960. There were no additions to the list of 21 states that have enacted into law the policy that the people have a paramount interest in the use and development of water, both surface and underground, and that the state should guide that development and use for the greatest public benefit, without waste. One reason for the "go slow" attitude is that the acute water shortages which existed 5 years ago have been relieved by more normal precipitation. Another is the desire to wait and find out how some of the newly enacted water rights legislation in other states works out.

After surveying a majority of its sister states' water laws, the Indiana Water Resources Commission arrived at the verdict that there is an absence of orderly law modernization throughout the nation. An example of the confused state of affairs is Wisconsin, where agricultural interests are pushing to abandon the time-honored riparian doctrine and substitute the priority allocation philosophy. The Wisconsin legislature created a water resources committee to study the problem. The demands of irrigation also have given impetus to a similar study of needed revisions in water rights law in Michigan. Many municipal leaders regard the proposed "Model Water Use Act" as an approach to uniformity. It provides for a state commission and incorporates the best features of various state and local laws. Its aim is comprehensive and paramount control over all the water resources of the state.[23]

State Water Rights Legislation

Two states that have forged ahead and carried out a system of appropriation are Iowa and Kansas. In 1957, Iowa law was revised to declare that all water, surface or ground, is public wealth. Administration and control of a permit system was placed in the Iowa Natural Resources Council. It has authority to hold hearings, administer oaths, take testimony, subpoena witnesses and order the taking of depositions. Since the enactment, there have been 1,556 applications for the beneficial use of water, of which 1,200 have been processed. Eighteen appeals to the council have been made, and four ultimately reached the courts.

The Kansas legislature in 1957 amended previous water statutes to make virtually all water use, including municipal use, subject to appropriation. In addition, the Kansas Water Resources Board is responsible for planning and general-policy formulation.

Given progressive leadership by Governor David Lawrence, Pennsylvania is alert to the need for additional water use legislation. The Joint State Government Commission, by virtue of

a resolution passed by the 1955–57 session of the Pennsylvania General Assembly, held a number of hearings on the matter. Now the state's Department of Forests and Waters is undertaking the preparation of its own model water law.

New Mexico seems to strengthen its regulation of water use more each year. In its 1959 session, the legislature declared the failure of any owner to exercise his appropriative right for 4 years results in forfeiture of the right. When the state engineer declares the existence of an underground basin, no well may be drilled, or the production of existing ones enlarged, unless a development plan is filed and a permit secured. The legislature also forbade any withdrawal of water in New Mexico for transportation to another state.

In New York, the legislature extended the functions of the State Water, Power, and Control Commission into the area of water resources planning and development. Formerly, its jurisdiction related mainly to the allocation of the water resources of the state among its various municipalities and subdivisions for public water supply purposes.

The New Jersey senate specifically provided a series of water development projects and placed a department of conservation and economic development in charge of the program. The water is delivered to purchasers upon application and after public hearing. The department is empowered to determine existing water rights on the Raritan River.

The California legislature authorized the State Department of Water Resources, under specified conditions, to make loans and grants to cities, counties, and districts for financing water projects. The department is authorized to loan up to $4,000,000 or grant $300,000 for one project. Prior approval must be obtained from the California Water Commission.

Washington lawmakers authorized water districts to execute contracts with cities and towns for the acquisition and operation of any water facilities or services. Public utility districts in Washington also were authorized to sell and convey to first-class cities which own water systems, all or part of a water system owned by the district, without the approval of the voters.

The Oregon legislature, down through the years, has been especially generous in the matter of protection of municipal water supplies. Several streams have been withdrawn from all appropriations for the benefit of particular cities. An example is the Bull Run River which furnishes the water supply for Portland. An interim committee on natural resources is concentrating on a policy that will secure the fullest utilization of water. One of the principal inquiries is whether priorities should be assigned to water for municipal and other domestic uses.

North Carolina moved to the forefront of a trend in many states toward consolidation of state water resources agencies.

Ohio established a seven-man water commission in the State Department of Natural Resources. The originally proposed regulatory powers were turned down to make the commission advisory. It may make studies, hold hearings, review and recommend water development plans, recommend appropriate means to relieve conflicts among water users, and propose policy and

legislation. Appropriations for the State Division of Water were increased 30 per cent, largely to implement the state-wide water plan inventory project. A new economic- and industrial-development department was given authority to create a special advisory committee to recommend plans for improving industrial and municipal water supplies.

The last session of the Kentucky legislature created, within the State Department of Conservation, a water resources study commission, the function of which is to make a continuous study relating to the proper use of the water resources of the state and formulate a comprehensive water law for Kentucky. This commission has been quite active and has made a complete study of the subject on a state-wide basis. There has been, however, no survey of any particular area or political subdivision of the state. The Kentucky legislature also approved the creation of water districts for the purpose of furnishing water to counties in the state.

Oklahoma overwhelmingly approved a constitutional amendment which permits incorporated cities and towns to cooperate with one another, and also with the state and federal governments, in the development and operation of water supplies. Issuance of bonds secured by water revenues for such joint development is authorized for the municipalities.

Connecticut's public water agencies were authorized to sell excess reserves to each other upon approval of the water resources commission.

Recent Texas legislation created a water development board with authority to give financial assistance to the various water districts in the construction of dams, reservoirs, and other necessary improvements. This board is advised as to the feasibility of projects by the Texas Board of Water Engineers. The statute establishes various water districts, many of them including cities, such as the Northeast Texas Municipal Water District and the West Central Texas Municipal Water District. Cities within a district use water from reservoirs, and the directors include a municipal representative.

The law authorized Bonham to form its own Bonham City Water Authority, and to construct or acquire all works, plants, and other facilities necessary for impounding, treating, and transporting water. Counties are now permitted to sell water not needed for county purposes to a municipal corporation and to make contracts concerning rates for any term not exceeding 40 years. It also was provided that whenever a water district lies wholly within two or more cities, a city in which the district lies may, if it so desires, take over the functions of the water district, together with its obligations. Private corporations were empowered to furnish water to cities and lay pipelines along or across state highways.

Water Resources Legislation

When speculation replaces fact in the courtroom, justice may be confused, if not thwarted. Nearly every judgment in water rights litigation is based upon the opinions of expert witnesses. The opinions are often based on complicated meteorologic, hydrologic, and geographic data.

The parade of distinguished hydrologists and geologists to the witness stand, each boasting impressive credentials, tends to bewilder rather than

to instruct the court where there is lack of basic data.

USGS stands ready to cooperate with municipal government in gathering and evaluating ground and surface water data, and many state agencies can also do the job, but a program to take stock of water conditions is needed to keep pace with demands for information.

Congress took a long stride in this direction in recent months. In a burst of oratory which covered six pages of the *Congressional Record,* the Senate established a committee to study the development and coordination of water resources.

According to Senator Mike Mansfield, who sponsored the resolution in company with former Senator James Murray, the intent of the committee will be to bring together basic information on what is needed in the field of water resources. It will provide for securing the opinions of technical experts and qualified laymen as to the best ways to proceed.

The 1959 Connecticut General Assembly authorized the State Water Resources Commission to make an inventory of the state's surface and ground waters. One reason for this was that a number of bills have been introduced recently in an effort to prevent the importation of water from undeveloped communities to larger areas of concentrated population where it is needed.

A study of ground water resources is one of the duties assigned New Jersey's new Department of Conservation and Economic Development.

Present and anticipated water demands must be determined as a prerequisite to federal assistance in the new Water Supply Act. This is certain to increase the gathering of basic data.

"We shall need a great many more stream gaging and weather stations as well as more precise data on the dependable yield from underground aquifers," stated General John L. Person of the US Army Corps of Engineers.

Pollution Control

Although the states have primary responsibility for controlling water pollution, it is apparent the federal government has a nationwide interest and responsibility in the quality and quantity of water available. Former Secretary of Health, Education, and Welfare Arthur S. Fleming recently raised the status of water contamination control activities in USPHS by approving the creation of its Division of Water Pollution Control. The Water Pollution Control Advisory Board, whose members are appointed by the President, has recommended continued federal leadership in protecting the nation's water resources.

The actual policing of pollution within the states is hardly a federal responsibility, however. Machinery to prevent the contamination of water resources has been set up by lawmakers in an increasing number of states. A model is California's Dickey Water Pollution Control Act. This act provides coordinated planning at regional levels—where the greatest number of affected interests are and where the moral and legal responsibilities lie. Primary responsibility is vested in nine regional water pollution control boards. Members represent water suppliers, users of irrigation water, industry, municipalities, and counties. These regulatory agencies formulate long-range plans and policies, prescribe and

enforce waste discharge regulations, and coordinate the interests of other agencies. Statewide policy is formulated by the California Water Pollution Control Board.

California can point to an impressive 8-year record of progress in pollution control achieved while a phenomenal 33 per cent increase in population was taking place. One of the most significant items reported by the control boards is that in the past 8 years every new major sewerage and industrial waste system has been provided with adequate treatment and disposal facilities.

In New York, the state's highest court, the court of appeals, sustained the power of the water pollution control board to classify and enforce standards for waters in the state according to a desired degree of cleanliness.[24] The court ruled that the board had power, properly delegated by the legislature, to set standards of purity for the state's waters and compel localities to maintain them. Many upstate riverside cities have insisted that they cannot afford to build required sewage plants.

The town of Westernport, Md., had been obtaining its water supply through a transmission line from a river some 6 miles away. For several years the water was chlorinated at its source and persons outside the town limits along the course of the transmission line were permitted to tap it. Westernport recently erected a filtration plant inside the town limits and planned to discontinue chlorination at the river. The town agreed to continue supplying water to users along the transmission line, on the condition that they sign a release from liability for illness resulting from the use of unchlorinated water. The State Board of Health brought an action to enjoin discontinuance of the supplying of water.

The court of appeals ruled that the State Board of Health does not have the power to require Westernport to supply water outside its corporate limits. If it continued to supply water outside the corporate limits, the board could require treatment or enjoin the delivery of contaminated water.[25]

In action for damages for the pollution by logging operations of a stream from which the water was taken for a community water system is noteworthy even though it did not specifically involve a municipality. The court held the owners were entitled to damages for the depreciation in the value of their property and for personal discomfort and annoyance caused by the necessity of hauling water to their premises for domestic use.[26]

There is sharp disagreement about the opening of public water facilities for any public recreational use. Two neighboring eastern state legislatures adopted laws on the subject during 1960. Connecticut ordered the criminal prosecution of any person who bathes or swims in or otherwise pollutes a reservoir. Rhode Island, on the other hand, provided that any municipal lake, pond, or reservoir used for water supply may be used by the public for boating and fishing.

Despite encouraging advances, too many communities and too many industries have failed to approach satisfactory standards. In the coming decade a stepped up antipollution campaign must accomplish:

1. Installation of new waste treatment facilities in municipalities and industries

2. Improvement and expansion of existing facilities to meet growing needs

3. Better protection of waterways
4. Education of the public to a better understanding of the overall problem.

References

1. *Federal Power Commission* v. *Oregon,* 349 US, 435 (1955).
2. *The Ivanhoe Irrigation District and the State of California* v. *Courtney McCracken,* 78 S. Ct. 1174, 357 US, 275 (1950).
3. *Nevada ex. rel. Shamberger, State Engineer* v. *United States,* US District Court, Nev. No. 1247 (1958).
4. *United States* v. *Fallbrook Public Utility District,* 165 F. Supp. 806 (1959).
5. *Arizona* v. *California,* 351 US, 977 (1956).
6. *Rank* v. *Krug,* 142 Fed. Supp. 1 (1956).
7. *City of Seattle* v. *State,* 154 Wash., Dec. 128 (1959).
8. *Orange County Water District* v. *Riverside, et al.,* 173 A.C.A. 167 (1959).
9. *Los Angeles* v. *San Fernando, Glendale, Burbank, et al.,* Los Angeles Superior Ct. No. 650079 (1960).
10. *San Luis Rey Water Conservation District* v. *Carlsbad Mutual Water Co.,* San Diego Case No. 184355 (1959).
11. *San Gabriel River Suit,* Los Angeles Superior Ct. No. 722647 (1960).
12. *State ex rel.* v. *Hance,* 165 O.S. 456 (1959).
13. *Township of Lansing* v. *City of Lansing,* 356 Mich. 338 (1959).
14. *Woodside Homes, Inc.,* v. *Morristown,* 26 N.J. 529 (1959).
15. *Rutan Estates* v. *Belleville,* 52 N.J. Superior Ct. 365 (1959).
16. *Ecloss Co., Inc.* v. *Parsippany-Troy Hills,* 55 N.J., Superior Ct. 552 (1959).
17. *Langan* v. *West Keansburg Water Company,* 51 N.J. Superior Ct. 41, Appellate Division (1959).
18. *California Water and Telephone Co.* v. *Public Utilities Commission,* 51 C 2d 478 (1959).
19. *City of Port Arthur* v. *Jefferson County Water Contol and Improvement District* (Tex.) No. 5, 320 S.W.2d 33 (1959).
20. *Bacon* v. *Kent-Ottawa Metropolitan Water Authority,* 354 Mich. 160 (1959).
21. *City of Los Angeles* v. *County of Inyo,* 167 A.C.A. 830, No. 5 (1959).
22. *Department of Highways of Pennsylvania* v. *Pennsylvania Public Utility Commission,* 190 Pa. Superior Ct. 1, 151 A. 2d 850 (1959).
23. ZIEGLER, W. L. The Model Water Use Act. *J. Am. Bar Assn.,* 44:689 (1958).
24. *City of Utica* v. *Water Pollution Control Board,* 5 N.Y. 2d, 164 (1959).
25. *State Board of Health* v. *Mayor, et al.,* 218 Md. 373, 146 A 2d 872 (1959).
26. *Drake et al.* v. *Smith et al.,* 54 Wash. Dec. 1949 (1959).

Notes and Comment

Pressure Drop in Pipe Bends and Elbows

Paul C. Ziemke

Cons. Engr., Clinton, Tenn.

The usual effect of elbows, bends, or other obstructions on the flow of liquids in pipes is to lower the critical velocity so that a fluid flowing streamline in a straight pipe may become turbulent upon traversing a bend, or existing turbulence may be increased. In bends or elbows, the degree of turbulence is altered by any change in the ratio of the radius of curvature, *R*, to the pipe diameter, *d*. Tests have indicated that the amount of increase in turbulence depends upon the properties of the fluid itself and is not constant for all fluids.

It is generally assumed that elbows of short radius produce a greater pressure drop than long-radius bends. This assumption is not borne out by tests, however, which show that if the mean radius of curvature of the elbow

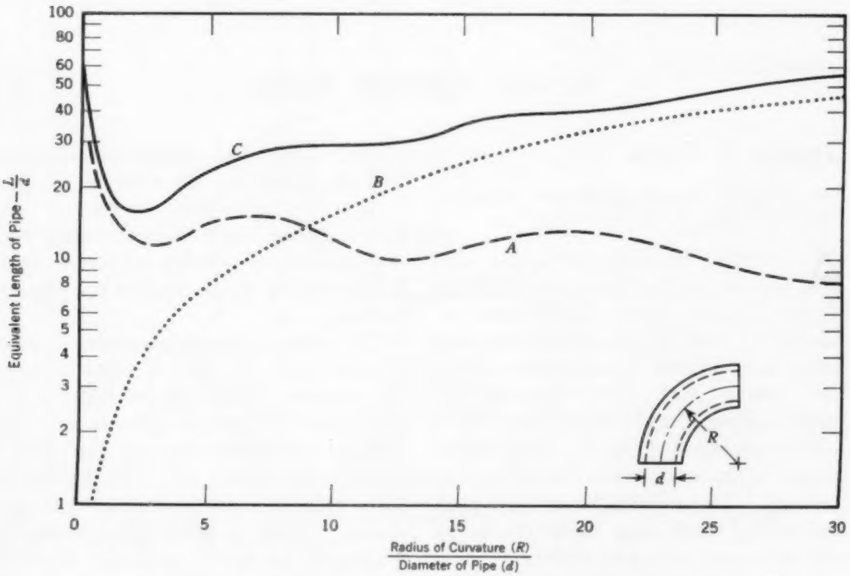


Fig. 1. Resistance to Flow in Pipe Bends and Elbows

Curve A—resistance due to curvature; Curve B—resistance due to pipe length; Curve C—total resistance in 90-deg bend.

is approximately 1.5–2 pipe diameters, the pressure drop is lower than that caused by a bend in the pipe having a radius of curvature of 5 pipe diameters. Actually, this does not take into consideration the straight length of pipe connected to the short-radius elbow; if the overall dimensions of the larger-radius bend were considered, a greater pressure drop would be indicated for the short-radius elbow construction.

By the use of colored filaments, the motion of water in its flow through curved glass pipes has been studied and an average curve of frictional resistance ratios is available. Curve *A* of Fig. 1 corresponds to this curve. Curve *B* shows the resistance due to the actual length of the bend; Curve *C* shows the total resistance of the pipe bend. Figure 1 indicates that the variation due to the properties of the various fluids is small and that for all practical purposes the curves given for water may be used for steam, gas, and other fluids.

It might be helpful to consider an example. Suppose one wished to determine the pressure drop, in terms of equivalent pipe length, caused by an expansion U bend made from 6-in. pipe, having a radius of curvature of 30 in. From Curve *C* of Fig. 1, for an R/d ratio of $30/6 = 5$ the equivalent pipe length for a quarter bend (90 deg) is 22 diameters. Thus, for 6-in. pipe, the equivalent length is $6 \times 22 = 132$ in., or 11 ft. An expansion U bend is made up of four quarter-bends; thus the approximate total resistance offered by this type of bend is $11 \times 4 = 44$ ft of 6-in. pipe.

Vacuum Sediment Tester

George J. Turre

San. Engr., Board of Water Comrs., Denver, Colo.

A VACUUM sediment tester, designed by the laboratory division of the Denver water department, is now being used for keeping visual record of the amount of suspended material (algae and other microscopic debris) present in Marston Lake water.

The apparatus (Fig. 2) uses cotton disks,* 1¼ in. in diameter, as a filtering medium. These disks have been used for testing milk and light cream in high-pressure sediment testers.

The cotton disk is inserted into a brass holder and rests on a fine brass screen. The disk holder is securely held in place on the bottom of the plunger by two brass setscrews. A rubber gasket recessed in the outer rim of the plunger assembly assures a tight fit against the inside wall of the copper cylinder.

The tester is simple to operate. The plunger with the disk is inserted into the cylinder; 600 ml of the water sample is poured into the cylinder and the plunger is raised, forcing the water through the disk. The disk holder is then removed by loosening the setscrews. Using a small, straight-tipped forceps or blade of a penknife, the disk is removed from the holder. Any suspended material removed is shown by the discoloration of the disk. The disks dry readily on blotting paper and

* Lintine; manufactured by Filter Products Div., Johnson & Johnson, Chicago, Ill.

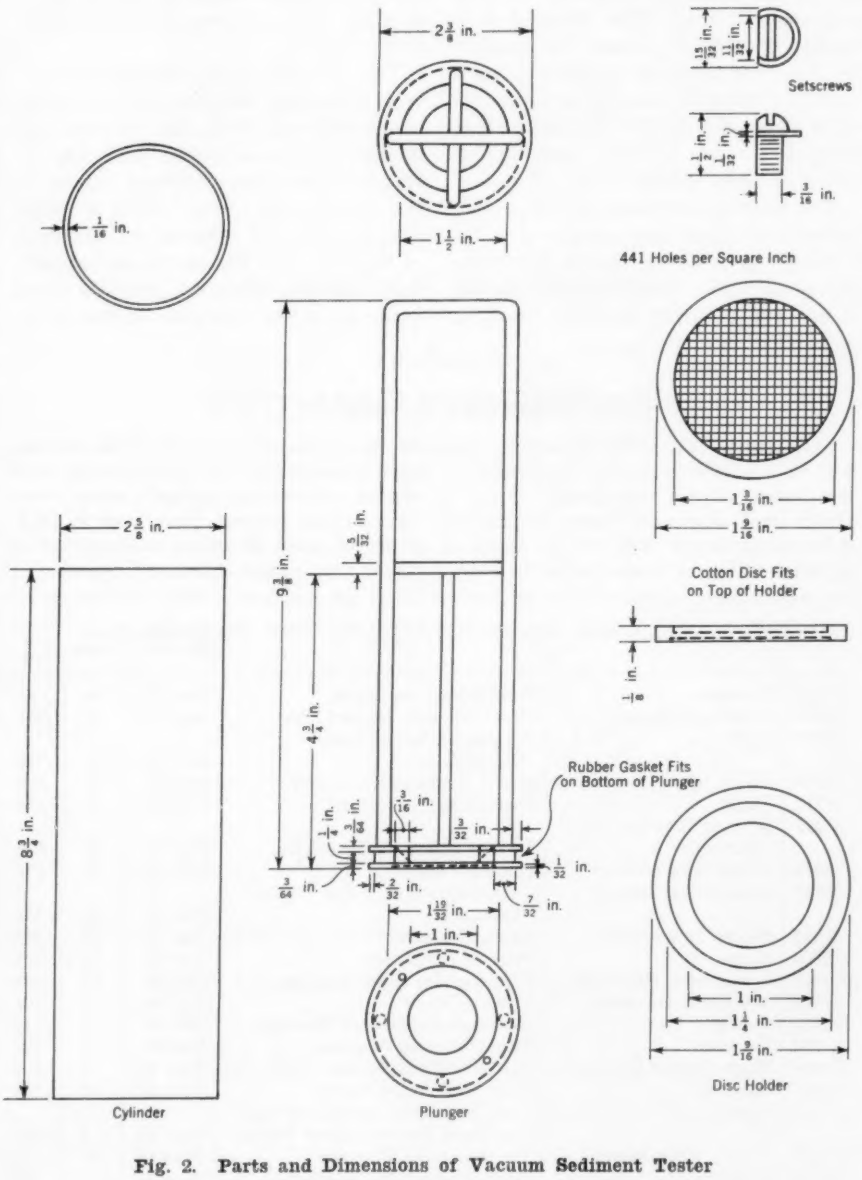


Fig. 2. Parts and Dimensions of Vacuum Sediment Tester

The outer cylinder is made of copper; all other parts are made of brass.

can be mounted on cards to form a permanent record. The value of permanent records is greatly enhanced if the disks are mounted on cards of such size that there is a space in which to write down the list of dominant algae recognized by special examination under the microscope.

The relative abundance of suspended material or algae in a sample of water is shown quite clearly by the discoloration of the disk. Although this method is not one of great accuracy, it is an excellent one for showing the variation of algal growths present in a public water supply.

The Denver water department has been impressed with the practical value of the sediment tester and believes that it should be used more generally by water works operators and others in the water works field. It is a useful and inexpensive addition to the tools of the field and laboratory and appeals to the layman because it provides visual evidence of the condition of the water.

Reprints Available

Reprints of the following articles, published in the JOURNAL during recent months, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 2 Park Avenue, New York 16, N.Y. A handling charge of $1 will be added on all orders under $5 unless accompanied by payment in US or Canadian funds or in AWWA Publication Discount Coupons.

Reprint No.	Author	Title	Issue of Journal	No. of Pages	Price per Copy
R906	Eastman	Bond Issue Campaigns	Sep 59	16	25¢
R907	Ingram & Moore	Fluoridation in Major Cities	Sep 59	16	25¢
R909	Howe	Progress in Saline Water Conversion	Oct 59	11	25¢
R910	Piper	Model Water Law	Oct 59	6	20¢
R911	Faust	Plastic Pipe Standards	Oct 59	4	15¢
R912	Setter, Regnier & Diephaus	Surface Water Radioactivity	Nov 59	25	40¢
R913	Committee Report	Pension Plans	Nov 59	4	15¢
R914	Committee Report	Compensation of Water Utility Managers	Dec 59	30	45¢
R915	Panel Discussion	Demand Meters	Dec 59	18	30¢
R1001	Sopp	Price of Accidents	Jan 60	11	25¢
R1002	Committee Reports	Chlorine and Alum Supplies	Jan 60	12	25¢
R1003	Schmid & Bauhahn	Thrust Blocks	Jan 60	7	20¢
R1004	Howson	Revenue, Rates, and Planning	Feb 60	9	25¢
R1005	Jackson	Tank Painting Practice	Feb 60	8	20¢
R1006	Task Group Report	Status of Fluoridation, 1958	Mar 60	7	20¢
R1007	Koenig	Well Stimulation Survey	Mar 60	18	30¢
R1008	Carl	Fire Protection Surveys as Indicators of Water System Status	Apr 60	8	20¢
R1009	Panel Discussion	Desalinization Processes	May 60	32	45¢
R1010	Koenig	Well Stimulation Economics	May 60	7	20¢
R1011	Editorial Statement	Style Manual for Journal Authors	May 60	16	25¢
R1012	Stuart	Main Extension Policies	Jul 60	8	20¢

ASA B58.1-1961
(AWWA A101-60)

AMERICAN STANDARD

for

VERTICAL TURBINE PUMPS

PUBLISHED BY AMERICAN WATER WORKS ASSOCIATION, INC.

Approved by American Standards Association Jan. 31, 1961

- Price of reprint—80¢ per copy
- Approximate date available—May 15, 1961

AMERICAN WATER WORKS ASSOCIATION
Incorporated
2 Park Avenue, New York 16, N.Y.

Table of Contents

Committee Personnel

Co-Chairmen: P. H. Brown, M. H. Owen

American Water Works Assn.
C. D. Bower
D. H. Cooper
W. L. Dornaus
N. C. Ebaugh
C. R. Erickson
Edward Farmer
A. D. Henderson
H. A. Knudsen
T. R. Mackay
M. H. Owen
J. L. Perhab
Dan Rankin

American Institute of Mining and Metallurgical Engineers
Ray Elner

American Public Works Assn.
C. E. Painter

American Society of Mechanical Engineers
P. H. Brown
Aladar Hollander
H. W. Iversen

Conference of State Sanitary Engineers
P. J. Houser

New England Water Works Assn.
E. B. Cobb

US Navy Department
M. J. Sassani

Anti-Friction Bearing Manufacturers Assn.
E. C. Denne
A. B. Jones Jr.

Latest Revisions to ASA B58.1

The latest changes in ASA B58.1 were approved by the American Standards Association on Jan. 31, 1961. The most important change was the inclusion of a new section (Part B) on submersible pumps. In addition, portions of the original standard (now Part A) were extensively revised, the major revisions occurring in Sec. A4.3 and A5.5.

Designation. The former designation, "B58.1-1955," has been changed to "B58.1-1961."

American Standard for

Vertical Turbine Pumps

Part A–Line Shaft Vertical Turbine Pumps

Section A1–Scope and Purpose

This standard is recommended as a guide for users of the line shaft vertical turbine pump in selecting new equipment. The suggested standards are to be considered a minimum requirement for a first-quality vertical turbine pump, but do not preclude the use of more elaborate specifications on the part of either user or manufacturer, nor is it the intent to restrict the use of any equipment not meeting the requirements of this standard should the user not consider such compliance necessary.

This standard is applicable primarily to pumps that are constructed of accepted standard materials of the best quality and workmanship.

Section A2–Definitions

2.1. *A line shaft vertical turbine* pump is a vertical-shaft centrifugal or mixed-flow pump with rotating impeller or impellers, with discharge from the pumping element coaxial with the shaft. The pumping element is suspended by the conductor system which encloses a system of vertical shafting used to transmit power to the impellers, the prime mover being external to the flow stream. The unit is used for pumping from open pools or closed suction systems. A basic pump consists of three elements, defined as follows:

2.1.1. *The pump bowl assembly* is either a single or multistage, centrifugal or mixed-flow vertical pump with discharge coaxial with the shaft. It has open, semiopen, or enclosed impellers. Assemblies are constructed for use with either open or enclosed line shafts.

2.1.2. *The column-and-shaft assembly* consists of the column pipe which suspends the pump bowl assembly from the head assembly and serves as a conductor for the fluid from the pump bowl assembly to the discharge head. Contained within the column pipe is the line shaft which transmits the power from the driver to the pump shaft. The line shaft is supported throughout its length by means of bearings and may be enclosed in a shaft-enclosing tube and generally lubricated with oil, or it may be open and lubricated with the fluid being pumped.

2.1.3. *The head assembly* consists of the base from which the column and shaft assembly and the bowl assembly are suspended, the discharge head, which directs the fluid into the desired piping system, and the driver.

2.1.3.1. *The driver* is the mechanism mounted on the discharge head which transmits the power to the top shaft. It contains means for impeller

adjustment and provides a bearing to carry the thrust load. It may or may not be a prime mover.

2.1.3.2. *In underground discharge,* the discharge tee is separated from the head assembly and installed in the column pipe at the desired distance below the head assembly.

2.2. *Types of drivers* are defined as follows:

2.2.1. *The vertical hollow-shaft motor drive* is an electric motor having a motor shaft which has been bored on the center of its axis to receive the top shaft of the pump. Impeller adjustment is made at the upper end of the motor, and a means to carry the thrust on a bearing within the motor is provided.

2.2.2. *The vertical hollow-shaft right-angle gear drive* is a gear mechanism having a shaft which has been bored on the center of its axis to receive the top shaft of the pump. The horizontal shaft of a gear drive receives its power from the prime mover and, through a pair of bevel gears, transmits it to the top shaft. Impeller adjustment is made at the upper end of the gear drive, and a means to carry the thrust on a bearing within the gear drive is provided.

2.2.3. *The vertical hollow-shaft belted drive* is a flat- or V belt–driven mechanism having a shaft which has been bored on the center of its axis to receive the top shaft of the pump. Impeller adjustment is made at the upper end of the belted drive, and a means to carry the thrust on a bearing within the belted drive is provided.

2.2.4. *The flexible-coupling drive* is a mechanism having a thrust bearing capable of carrying the pump thrust, providing means of impeller adjustment, and having a flexible coupling. The top of this driver is designed to mount solid-shaft prime movers, incapable of supporting external thrust, including electric motors, steam turbines, radial engines, or any other type of prime mover having a solid shaft and suitable for mounting with the shaft in a vertical position.

2.2.5. *The combination drive* includes means for operating the pump with two or more drivers.

2.3. *The datum* shall be taken as the elevation of that surface from which the weight of the pump is supported. This is normally the elevation of the underside of the discharge head or head base plate.

2.4. *The setting* is the nominal distance in feet from the datum to the column pipe connection at the bowl assembly.

2.5. *The static water level* is the vertical distance in feet from the datum to the level of the free pool while no water is being drawn from the pool.

2.6. *The pumping water level* is the vertical distance in feet from the datum to the level of the free pool while the specified fluid flow is being drawn from the pool.

2.7. *Drawdown* is the difference in feet between the pumping water level and the static water level.

2.8. *Specific yield,* expressed in gpm (US gallons per minute) per foot of drawdown, is the rate of flow from the free pool, divided by the drawdown, in feet.

2.9. *The capacity of the pump* is the volume rate of flow (Q), expressed in gpm, produced by the pump, calculated for specified conditions.

2.10. *The pump speed of rotation* (N) is the rate of rotation of the pump shaft, expressed in rpm (revolutions per minute).

2.11. *Head* is a quantity used to express the energy content of the liquid per unit weight of the liquid, referred to any arbitrary datum. In

terms of foot-pounds of energy per pound of liquid being pumped, all head quantities have the dimension of feet of liquid.

2.11.1. *Head below datum* (h_b) is the vertical distance in feet between the datum and the pumping level.

2.11.2. *Head above datum* (h_a) is the head measured above the datum, expressed in feet of liquid, plus the velocity head (Sec. 2.11.3) at the point of measurement.

2.11.3. *Velocity head* (h_v) is the kinetic energy per unit weight of the liquid at a given section. Velocity head is specifically defined by the expression:

$$h_v = \frac{v^2}{2g}$$

2.11.4. *Suction head* (h_s) is the algebraic sum of the pressure head (measured at the elevation of the suction case lower connection) and the velocity head at that point. The value of the suction head is not required when the surface of the liquid being pumped is exposed to atmospheric pressure.

2.11.5. *Pump total head* (H) is the bowl assembly head (Sec. 2.11.6) minus the column loss (Sec. 2.12) and discharge head loss. This is the head generally called for in pump specifications.

2.11.5.1. *On open-suction installations,* it is the sum of the head below datum and the head above datum.

2.11.5.2. *On closed-suction installations,* it is the algebraic difference of the suction head, the distance between the suction case flange and the datum, and the head above datum.

2.11.6. *Bowl assembly head* (h_l) is the energy imparted to the liquid by the pump (expressed in foot-pounds per pound of liquid). It is the head of a pump installed with a minimum length of column and shaft, as in the manufacturer's laboratory.

2.11.6.1. *On open-suction installations,* it is the sum of the head below datum and the head above datum.

2.11.6.2. *On closed-suction installations,* it is the algebraic difference of the suction head, the distance between the suction case flange and the datum, and the head above datum.

2.12. *The column loss* (h_c) is the value of the head loss (expressed in feet) due to the flow friction in the column pipe. This value is subtracted from the bowl assembly head to predict the pump total head.

2.13. *The line shaft loss* (hp_1) is the power (expressed in horsepower) required because of the rotation friction of the line shaft. This value is added to the bowl assembly input (Sec. 2.14.3) to predict the pump input (Sec. 2.14.1).

2.14. *Power* is expressed in units of horsepower. One horsepower is equivalent to 550 ft-lb per second, 33,000 ft-lb per minute, 2,545 Btu per hour, or 0.746 kw.

2.14.1. *Pump input* is the power delivered to the line shaft, expressed in horsepower.

2.14.2. *Driver power input* is the power input to the driver, expressed in horsepower.

2.14.3. *Bowl assembly input* is the power delivered to the pump shaft, expressed in horsepower. It is the pump input of a pump installed with a minimum of column and shaft, as in the manufacturer's laboratory.

2.15. *Output* is defined as follows:

2.15.1. *Pump output* is defined as $\frac{QH}{3{,}960}$ for water having a specific weight of 62.4 lb per cubic foot. It is expressed in horsepower.

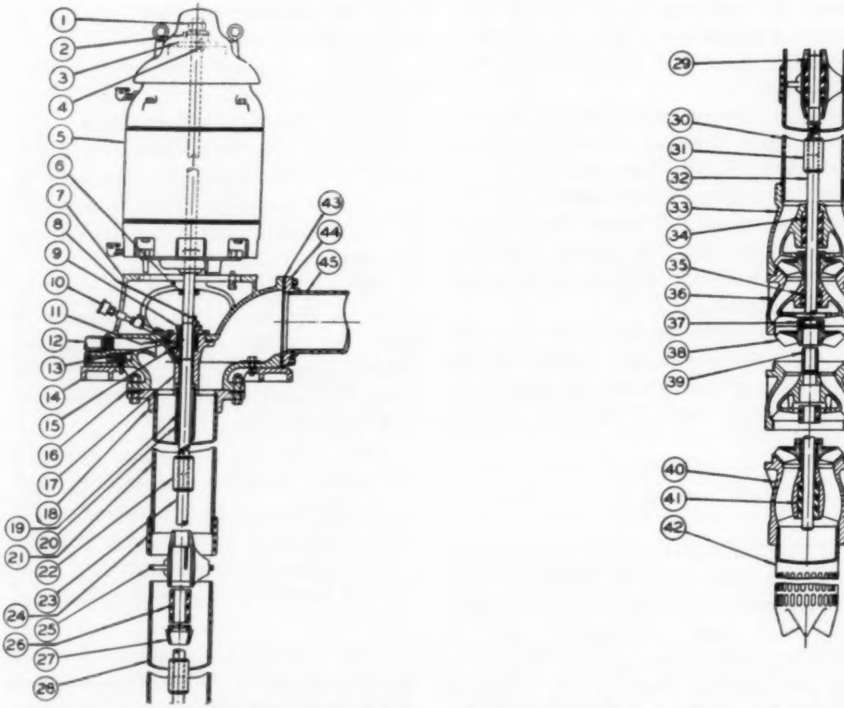


Fig. 1. Open Line Shaft Pump (Surface Discharge, Threaded Column and Bowls)

2.15.2. *Bowl output* is defined as $\frac{Qh_l}{3,960}$ for water having a specific weight of 62.4 lb per cubic foot. It is expressed in horsepower.

2.16. *Efficiency* is defined as follows:

2.16.1. *Pump efficiency* (E_p) is the ratio of pump output to pump input, expressed in per cent.

2.16.2. *Overall efficiency* (E) is the ratio of pump output to driver power input, expressed in per cent.

2.16.3. *Driver efficiency* (E_g) is the ratio of the driver output to the driver input, expressed in per cent.

2.16.4. *Bowl assembly efficiency* (E_l), is the ratio of the bowl output to the bowl assembly input, expressed in per cent.

Section A3—Nomenclature

Sec. A3.1—Standard Nomenclature

Table 1 lists the name of the part, together with its function and typical material. The material listed is intended to be typical only and does not constitute a recommendation. The part number refers to the numbers in Fig. 1 and 2.

Sec. A3.2—Order Form

A recommended specification form for use in purchasing deep well turbine pumps is given in Table 2.

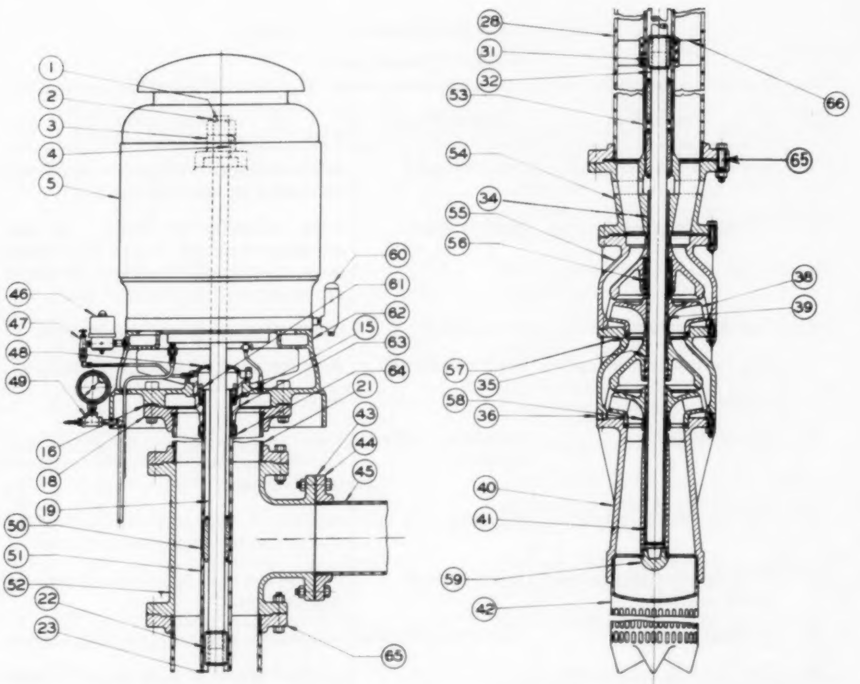


Fig. 2. Enclosed Line Shaft Pump (Underground Discharge, Flanged Column and Bowls)

Section A4—General Specifications

Sec. A4.1—General

4.1.1. *Descriptive matter.* The bidder shall submit, with his proposal, sufficient descriptive material or outline drawings to demonstrate compliance with these specifications, and a performance curve showing pump total head, pump input horsepower, and pump efficiency over the specified head range for the installed pump.

4.1.2. *Sanitary codes.* The pump shall conform to the sanitary codes governing the installation. The purchaser shall furnish, as a part of these specifications, all information necessary for the construction of the pump to meet these requirements.

4.1.3. *Pump base.* A suitable base of cast iron or fabricated steel shall be provided for mounting the driver and supporting the pump column. The (aboveground or below ground) discharge outlet shall be flanged, or a nipple with a companion flange shall be furnished for a 125-lb ASA B16.1 connection, as specified.

4.1.4. *Driver.* With electric power, the motor shall be of the full-voltage

TABLE 1

Standard Nomenclature

Part No.	Name of Part	Typical Material	Function of Part
1	Top shaft adjusting nut	brass or steel	means of adjusting impellers vertically by raising or lowering shaft
2	Adjusting-nut lock screw	steel or brass	locks adjusting nut in place so that adjustment cannot change while pump is in operation (furnished as simple pin or screwed or threaded pin)
3	Top drive coupling	semisteel	couples top shaft with motor rotor
4	Key for top drive coupling	cold-rolled steel	keys top shaft to top drive coupling
5	Motor		drives pump
6	Water slinger	neoprene, rubber, or steel	keeps packing box leakage from shooting directly into hollow shaft of motor or driver unit
7	Surface discharge head	cast iron	supports driver and pump column; discharges water from pump column
8	Stuffing box stud bolts and hexagonal nuts	brass or steel	fastened in stuffing box to adjust stuffing box gland
9	Stuffing box gland	cast iron or bronze	compresses and holds packing in place
10	Stuffing box lubrication fittings		conduct grease to packing and journal bearing
11	Stuffing box gasket		placed under seat of packing containers to prevent leakage
12	Prelubrication fittings		conduct water to keep water-lubricated bearings wet during starting cycle
13	Top shaft sleeve	monel or stainless steel	sleeve operating within packed area in top shaft on open line shaft pumps
14	Head base plate	cast iron or steel	plate or casting that supports discharge head and may become permanent part of foundation after initial installation
15	Packing		flexible material which can be compressed by stuffing box gland in stuffing box so as to prevent leakage of fluid being pumped
16	Top column flange gasket		seals joint between flange faces
17	Stuffing box	cast iron	guides shaft and holds packing
18	Top column flange	cast iron	couples column to discharge head

TABLE 1—*Standard Nomenclature (contd.)*

Part No.	Name of Part	Typical Material	Function of Part
19	Top shaft	steel	coupled to line shaft; connects latter to driver
20	Stilling tube	steel	suspended around top shaft from packing box to reduce flow of abrasive material into packing box
21	Top column pipe	steel	first section of column pipe below discharge
22	Line shaft coupling	steel	used to join all sections of line shafting throughout unit
23	Line shaft	steel	Those sections of line shafting between top shaft and pump shaft
24	Column pipe coupling	steel	couples sections of column pipe
25	Open line shaft bearing retainer	bronze	used to support line shaft bearing; generally located at end of each section of column pipe
26	Open line shaft bearing	rubber	bearing held in bearing retainer to guide line shafting of pump
27	Open line shaft bearing retainer cap	bronze	locks bearing within bearing retainer
28	Column pipe	steel	column pipe between top column and bottom column pipe; usually made of standard steel pipe
29	Open line shaft sleeve	monel or stainless steel	sleeve operating as journal for bearings
30	Bottom column pipe	steel	first section of column immediately above discharge case or discharge bowl
31	Pump shaft coupling	steel	connects bottom shaft to impeller shaft; may be tapped with two different thread diameters
32	Pump shaft	stainless steel	supports impellers; coupled to line shaft
33	Discharge bowl	cast iron	receives flow from top impeller and guides it to pump column
34	Top bowl bearing	bronze or rubber	supports portion of pump shaft
35	Intermediate bowl bearing	bronze or rubber	supports portion of pump shaft
36	Intermediate bowl	cast iron	guides flow received from impeller to next impeller above
37	Impeller collet lock nut	bronze	used to pull impeller on collet; locks collet in place

TABLE 1—*Standard Nomenclature* (*contd.*)

Part No.	Name of Part	Typical Material	Function of Part
38	Impeller	bronze or cast iron	pumping element; receives water and impels it centrifugally to bowl passage
39	Impeller lock collet	steel	locks impeller to shaft
40	Suction case	cast iron	receives water from well; guides to first impeller
41	Suction case bearing	bronze	supports bottom portion of pump shaft
42	Strainer	galvanized steel or bronze	keeps large foreign material out of pumps
43	Discharge companion flange gasket	rubberized cloth or rubber	seals joints between surface discharge head or underground elbow and companion flange
44	Discharge companion flange	cast iron	connects discharge pipe to integrally cast flanges on discharge head or underground discharge elbow
45	Discharge pipe	steel	conducts water away from pump.
46	Solenoid oil valve		starts oil flow to line shaft bearings when motor is started
47	Sight-feed oil valve		means of adjusting oil flow to line shaft bearings
48	Tubing tension nut cap	cast iron	covers top of oil tube to prevent entrance of dust
49	Water level indicator assembly		determines water level in well
50	Enclosed line shaft bearing	bronze	guides and supports shaft section may couple connecting sections of enclosing tube
51	Shaft-enclosing tube	steel	encloses line shaft
52	Underground discharge tee	cast iron	changes flow from vertical to horizontal when discharge is below surface; also forms part of column
53	Tubing adapter	cast iron or steel	encloses shaft; adapts standard tube size to off-standard tube size
54	Discharge case	cast iron	guides flow to pump column
55	Top bowl	cast iron	receives flow from top impeller and guides it to discharge case
56	Bypass seal		restricts leakage from bowls to oil tube; seals off bowl passages from enclosing tube

TABLE 1—*Standard Nomenclature* (*contd.*)

Part No.	Name of Part	Typical Material	Function of Part
57	Impeller seal ring	rubber, bronze, or hardened steel	provides water seal at impeller
58	Suction case sand collar	bronze	prevents sand from entering suction case bearing
59	Suction case plug	black iron	plugs suction case grease container
60	Oil gage assembly for motor bearings		shows level of oil in motor oil reservoir
61	Packing follower	cast iron	tightens packing around enclosing tube
62	Underground discharge head	cast iron	supports motor above foundation when discharge is below surface
63	Tubing tension nut	semisteel	maintains tension on shaft-enclosing tube
64	Lock nut for tubing tension nut	cast brass	locks tubing nut
65	Column flange	steel	joins sections of column pipe
66	Enclosing tube stabilizer	bronze or rubber	stabilizes shaft-enclosing tube

starting, vertical hollow-shaft squirrel-cage induction type, and shall comply with ASA C50.2. The connection to the pump shaft shall be through a coupling or clutch in the motor head. The motor shall be of the proper size to drive the pump continuously over the specified operating range without the load exceeding the service factor. The motor shall be rated as dripproof 40°C rise design with 1.15 service factor. (Standard motor voltages are 208, 220, 440, 550, 2,300.)

With an engine drive, the power shall be applied to the pump shaft through a right-angle gear set. The connection to the vertical shaft shall be through a coupling or clutch in the gear head. The horizontal shaft shall rotate in the same direction as the engine drive, and shall be connected to the engine by a flexible-shaft coupling.

An optional method of driving, for an engine or horizontal electric motor, shall be a belt head—either a flat belt on a modified cylindrical pulley, or a V belt on a V-groove pulley.

Rotation of the vertical shaft shall be counterclockwise when viewed from above.

A thrust bearing of ample capacity to carry the weight of all rotating parts plus the hydraulic thrust shall be incorporated into the driver as an integral part of it. The bearing shall be of such a size that the average life rating is no less than 5 years' continuous operation.

4.1.5. *Suction pipe and strainer.* A strainer, if required, shall have a

TABLE 2

*Suggested Specification Form for the Purchase of ASA Vertical Turbine Pumps**

1. Purchaser ....
2. Address ....
3. Installation site ....
4. Job No. .... Item No. .... Quote No. ....
   P.O. No. ....
5. No. required .... By .... Date ....
6. Driver: Electric motor .... Right-angle gear .... Belt ....
   Engine ....

Pump Operating Conditions

7. Capacity .... gpm; Maximum speed .... rpm
   Elevation at site .... ft
8. Pumping level below ground level at rated capacity .... ft
9. Pumping head above ground level, including discharge pipe friction .... ft
10. Rated total pump head (Lines 8 plus 9, above) .... ft
11. Operating range: Minimum total head .... ft
    Maximum total head .... ft
12. Pump setting .... ft

Description of Well

13. Minimum inside diameter of well or casing .... in., to a depth of .... ft
14. Total depth of well .... ft
15. Well straight to a depth of .... ft (a well is considered straight if a 20-ft long cylinder equal to a bowl diameter will not bind when lowered to a depth equal to the pump setting)
16. Static water level below ground surface .... ft
17. Pumping drawdown .... ft at .... gpm
18. Well developed to .... per cent of rated pump capacity
19. Sand in water: None .... Average .... High .... Unknown ....
20. Gas in water: None .... Average .... High .... Unknown ....
21. Water corrosive: Yes .... No ....
22. Corrosive substances ....
    Materials to resist corrosion ....

Driver Data

23. Electric power available ....: Maximum horsepower ....
    Volts .... Cycles .... Phase ....
24. Other driver available ....: Maximum horsepower ....
    (Gas) (Gasoline) (Diesel) engine; Drive: (Direct) (Belt)
25. V-belt size ....: Groove type sheave diameter ....
    Flat belt width ....; Pulley diameter ....

Connections and Accessories

26. Discharge flange .... in., 125-lb ASA standard threaded companion flange aboveground standard (if underground discharge desired, centerline shall be .... ft below ground level)
27. Strainer required: Yes .... No ....
28. Solenoid oiler required: Yes .... No .... Voltage available ....
29. Prelube water tank required: Yes .... No ....
30. Automatic controls required: Time delay relay .... Float switch ....

Pumps are to be furnished in accordance with ASA Standard B58.1, with the following exceptions:

* For submersible pumps, Item 6 would include electric motor only and Items 24, 25, and 28–30 do not apply.

net inlet area equal to at least three times the suction pipe area. The maximum opening shall be not more than 75 per cent of the minimum opening of the water passage through the bowl or impeller.

Sec. A4.2—Oil-Lubricated Pump and Column

4.2.1. *Pump bowls.* The castings shall be free of blow holes, sand holes, and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated capacity or $1\frac{1}{2}$ times shutoff head, whichever is greater. Bowls may be equipped with replaceable seal rings on the suction side of enclosed impellers. The discharge case shall be provided with a means of reducing to a minimum the leakage of water into the shaft enclosing tube, and must have bypass ports of sufficient area to permit the escape of water that leaks through the seal or bushing.

4.2.2. *Impellers.* The impellers shall be of the enclosed or semiopen type, statically balanced. They shall be securely fastened to the impeller shaft with keys, taper bushings, or lock nuts. They shall be adjustable vertically by means of a nut in the motor head.

4.2.3. *Pump shaft.* The pump shaft shall be ground, and it shall be supported by bearings above and below each impeller. The minimum size of the shaft shall be determined by the following formula for steady loads of diffuser type pumps with shaft in tension due to hydraulic thrust:

$$D^3 = \frac{16}{\pi S}\sqrt{\left(\frac{FD}{8}\right)^2 + \left(\frac{396{,}000P}{2\pi N}\right)^2}$$

or:

$$S = \sqrt{\left(\frac{2F}{\pi D^2}\right)^2 + \left(\frac{321{,}000P}{ND^3}\right)^2}$$

or:

$$P = \frac{ND^3}{321{,}000}\left[S^2 - \left(\frac{2F}{\pi D^2}\right)^2\right]^{\frac{1}{2}}$$

in which D is the shaft diameter (in inches) at the root of the threads or the minimum diameter of any undercut; F is the total axial thrust (in pounds) of the shaft, including hydraulic thrust plus the weight of the shaft and all rotating parts supported by it; S is the combined shear stress (in pounds per square inch); P is the power transmitted by the shaft (in horsepower); and N is the rotation speed of the shaft (in revolutions per minute).

The maximum combined shear stress (S) shall not exceed 30 per cent of the elastic limit in tension or be more than 18 per cent of the ultimate tensile strength of the shafting steel used.

The straightness and machining tolerances shall be the same as those given under "Line Shafts" (Sec. 4.2.4).

4.2.4. *Line shafts.* The line shafts shall be ground, of carbon steel, and of the size that will conform to Sec. 4.2.3. For convenience, Tables 4 and 5 may be used when the shaft material complies with the physical properties set forth in Fig. 3–5. The shaft shall be furnished in interchangeable sections having a nominal length of 10 ft. To insure accurate alignment of the shafts, they shall be straight within 0.005-in. total indicator reading for a 10-ft section; the butting faces shall be machined square to the axis of the shaft; the maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.002 in. in 6 in. The line shaft shall be coupled with steel couplings, which shall be designed with a safety factor of $1\frac{1}{2}$ times the shaft safety factor and shall have a left-hand thread to tighten during pump operation.

4.2.5. *Line shaft bearings.* The line shaft bearings, which also have integral couplings, shall be spaced not more than 5 ft apart. The maximum angle error of the thread axis to the bore axis shall be within 0.001 in. per inch of thread length. The concentricity of the bore to the threads shall be within 0.005 in. of the total indicator reading. The bearings must contain oil grooves or a separate bypass hole which will readily allow the oil to flow through and lubricate the bearings below.

4.2.6. *Shaft-enclosing tube.* The shaft-enclosing tube shall be made of extra-strong steel pipe in interchangeable sections not more than 5 ft in length. Each section shall be machined and threaded relative to accurately prepared diameters at extreme ends of the tube or by means of locating devices mounted thereon. The ends of the enclosing tube shall be square with the axis and shall butt to insure accurate alignment. The maximum angle error of the thread axis relative to the bore axis shall be 0.001 in. per inch of thread length. The enclosing tube shall be stabilized in the column pipe by stabilizers.

4.2.7. *Discharge column pipe.* The pipe size shall be such that the friction loss will not exceed 5 ft per 100 ft, based on the rated capacity of the pump. The pipe shall be furnished in interchangeable sections having a nominal length of 10 ft; shall be of standard weight, conforming to the specifications in Table 3; and shall be connected by threaded-sleeve couplings. The ends of each section of pipe may be faced parallel and machined with threads to permit ends to butt, or they may be fixed with ASA standard tapered pipe threads.

4.2.8. *Discharge head assembly.* At the surface discharge head or underground discharge head, a proper lubrication system must be installed; it shall consist of a manually operated sight-feed drip lubricator and an oil reservoir of ample capacity, constructed as an integral part of the head or as a separate auxiliary unit. A tubing tension nut shall be installed in the head to allow tension to be placed on the shaft enclosing tube. Provision must be made for sealing off the threads at the tension nut.

Sec. A4.3—Water-Lubricated Pump and Column

4.3.1. *Pump bowls.* The castings shall be free of blow holes, sand holes, and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the pressure at rated capacity or $1\frac{1}{2}$ times shutoff head, whichever is greater. Bowls may be equipped with replaceable seal rings on the suction side of enclosed impellers.

4.3.2. *Impellers.* The impellers shall be of the enclosed or semiopen type, statically balanced. They shall be securely fastened to the impeller shaft with keys, taper bushings, or lock nuts. They shall be adjustable vertically by means of a nut in the motor head.

4.3.3. *Pump shaft.* The pump shaft shall be ground, and it shall be supported by bearings above and below each impeller. The minimum size of the shaft shall be determined by the following formula for steady loads of diffuser type pumps with shaft in tension due to hydraulic thrust:

$$D^3 = \frac{16}{\pi S}\sqrt{\left(\frac{FD}{8}\right)^2 + \left(\frac{396{,}000P}{2\pi N}\right)^2}$$

or:

$$S = \sqrt{\left(\frac{2F}{\pi D^2}\right)^2 + \left(\frac{321{,}000P}{ND^3}\right)^2}$$

or:

$$P = \frac{ND^3}{321{,}000}\left[S^2 - \left(\frac{2F}{\pi D^2}\right)^2\right]^{\frac{1}{2}}$$

in which D is the shaft diameter (in inches) at the root of the threads or the minimum diameter of any undercut; F is the total axial thrust (in pounds) of the shaft, including hydraulic thrust plus the weight of the shaft and all rotating parts supported by it; S is the combined shear stress (in pounds per square inch); P is the power transmitted by the shaft (in horsepower); and N is the rotation speed of the shaft (in revolutions per minute).

The maximum combined shear stress (S) shall not exceed 30 per cent of the elastic limit in tension or be more than 18 per cent of the ultimate tensile strength of the shafting steel used.

The straightness and machining tolerances shall be the same as given under "Line Shafts" (Sec. 4.3.4).

4.3.4. *Line shafts.* The line shafts the size that will conform to Sec. 4.3.3. For convenience, Tables 4 and 5 may be used when the shaft material com plies with the physical properties set forth in Fig. 3–5. The shaft shall be furnished in interchangeable sections having a nominal length of 10 ft. To insure accurate alignment of the shafts, they shall be straight within 0.005-in. total indicator reading for a 10-ft section; the butting faces shall be machined square to the axis of the shaft; the maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.002 in. in 6 in. The line shaft shall be coupled with steel couplings, which shall be designed with a safety factor of $1\frac{1}{2}$ times the shaft safety factor and shall have a left-hand thread to tighten during pump operation. The shaft shall be provided with a noncorrosive wearing surface at the location of each guide bearing.

4.3.5. *Line shaft bearings.* The shaft bearings shall be designed for vertical turbine pump service, to be lubricated by the liquid pumped. They shall be mounted in bearing retainers which shall be held in position in the column couplings by means of the butted ends of the column pipes. The bearings shall be spaced at intervals of not more than 10 ft.

4.3.6. *Discharge column pipe.* The pipe size shall be such that the friction loss will not exceed 5 ft per 100 ft, based on the rated capacity of the pump. The pipe shall be furnished in interchangeable sections having a nominal length of 10 ft; shall be of standard weight, conforming to the specifications in Table 3; and shall be connected with threaded sleeve type couplings. The ends of each section of column pipe shall be faced parallel and the threads machined to such a degree that the ends will butt, to insure proper alignment when assembled.

4.3.7. *Discharge head assembly.* The pump shall be provided with a discharge head of the surface or underground type, as required, and shall be provided with a shaft packing box and a renewable bronze bushing. The head shall also include a prelubrication connection to wet down the line shaft bearings adequately before starting the pump.

4.3.8. *Prelubrication.* Provisions shall be made by the manufacturer to prelubricate line shaft bearings adequately before the pump is started, on installations with a setting of more than 50 ft.

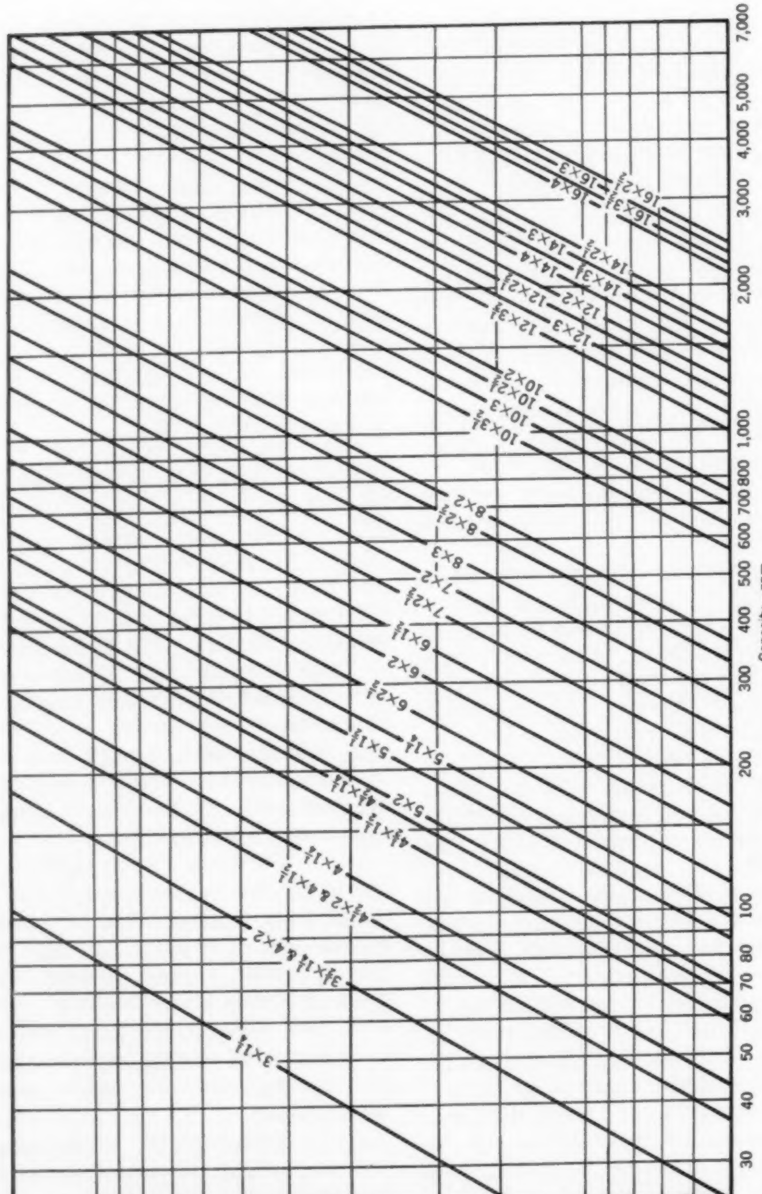


Fig. 3. Friction Loss Chart for Standard Pipe Column (See Note on Facing Page)

If manual control is used and a source of fresh water under pressure is not available, a prelubricating tank, with the necessary valves and fittings to connect it to the pump, shall be provided. The size of the tank shall be adequate to permit thorough wetting of all the line shaft bearings before the power is applied, with an adequate reserve for repeating the process in the event that the pump does not start the first time for any reason.

If an automatic system is used, bypass fittings or other suitable means shall be provided to bring the prelubricating water from ahead of the check valve into the prelubricating opening of the discharge head. This normally implies the use of a time delay relay in the starting system and a solenoid valve in the prelubricating line.

4.3.9. *Ratchets.* Water-lubricated vertical turbine pumps having a setting of 50 ft or more shall be provided with a nonreverse mechanism in the motor to protect the line shaft bearings from reverse rotation when the power is interrupted and the water empties from the discharge column.

Section A5—Engineering Data

Sec. A5.1—Discharge Column Pipe

Diameters and weights of standard discharge column pipe sizes are given in Table 3.

Sec. A5.2—Column Friction Loss

The column friction chart (Fig. 3) should be used to determine the loss in head due to column friction. This chart has been compiled from data on head losses where the flow is between the inside diameter of the column pipe and the outside diameter of the shaft-enclosing tube.

For open line shafting, the losses shown on Fig. 3 should be used by assuming the losses equal to those indicated on the chart for a shaft-enclosing tube of a size that would normally enclose the open line shaft in question.

Explanation of Fig. 3

Diagonals are labeled to show nominal diameters (in inches) of outer pipe column and inner shaft-enclosing tube. For the outer pipe columns, the calculations used in constructing the chart were based on inside diameters, which are close to the nominal sizes for pipe up to and including 12 in. (for example, 10 in. = 10.2-in. ID); in sizes 14 in. and larger, the diameters shown are equivalent to the outside diameter of pipe ⅜-in. wall thickness (for example, 16 in. = 15¼-in. ID). For the inner columns (shaft-enclosing tubes), the calculations were based on the outside diameters of standard or extra-heavy pipe. Thus, "8 × 2" on the chart is actually 8.071 × 2⅜, and "16 × 3" is 15¼ × 3½. (Chart reprinted by permission of Hydraulic Institute, Inc.)

Sec. A5.3—Discharge Head Loss

The discharge head loss chart (Fig. 4) should be used to determine the

TABLE 3

Diameters and Weights of Standard Discharge Column Pipe Sizes

Nominal Size (ID) *in.*	OD *in.*	Weight per Foot (Plain Ends) *lb*
2½	2.875	5.79
3	3.500	7.58
3½	4.000	9.11
4	4.500	10.79
4½	5.000	12.54
5	5.563	14.62
6	6.625	18.97
7	7.625	22.26
8	8.625	24.70
9	9.625	28.33
10	10.750	31.20
12	12.750	43.77
14*	14.000	54.57
16*	16.000	62.58

* OD.

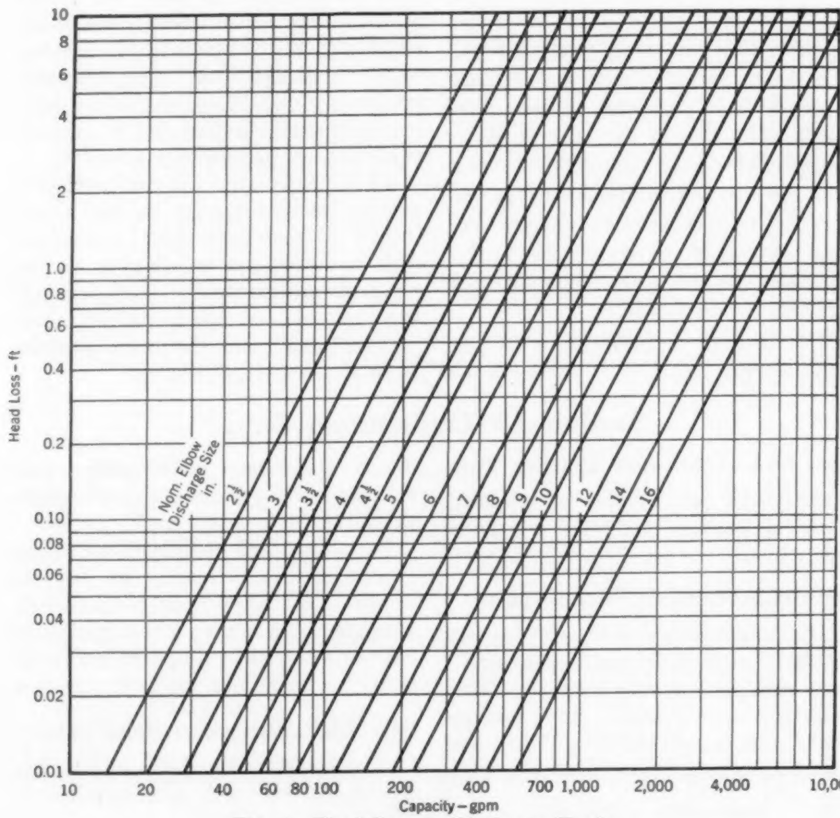


Fig. 4. Head Loss in Discharge Heads

hydraulic losses in the discharge head. Losses in discharge heads vary with the size of the head, the design of the head, and the size of tubing or shaft, column, and discharge pipe used. Figure 4 represents estimated average losses. Where extreme accuracy is imperative, actual loss measurements in the discharge head to be used—with the correct tubing or shaft, column, and discharge pipe—should be specified on the bid request by the purchaser.

Sec. A5.4—Mechanical Friction

The mechanical-friction chart (Fig. 5) should be used to determine the added horsepower due to mechanical friction in rotating the line shaft. The chart was compiled from test data submitted by representative turbine pump manufacturers. Variations in designs

Explanation of Fig. 5

The chart shows values for enclosed shaft with oil or water lubrication and drip feed, or for open shaft with water lubrication. For enclosed shaft with flooded tube, read two times the value of friction shown on the chart. (Chart reprinted by permission of Hydraulic Institute, Inc.)

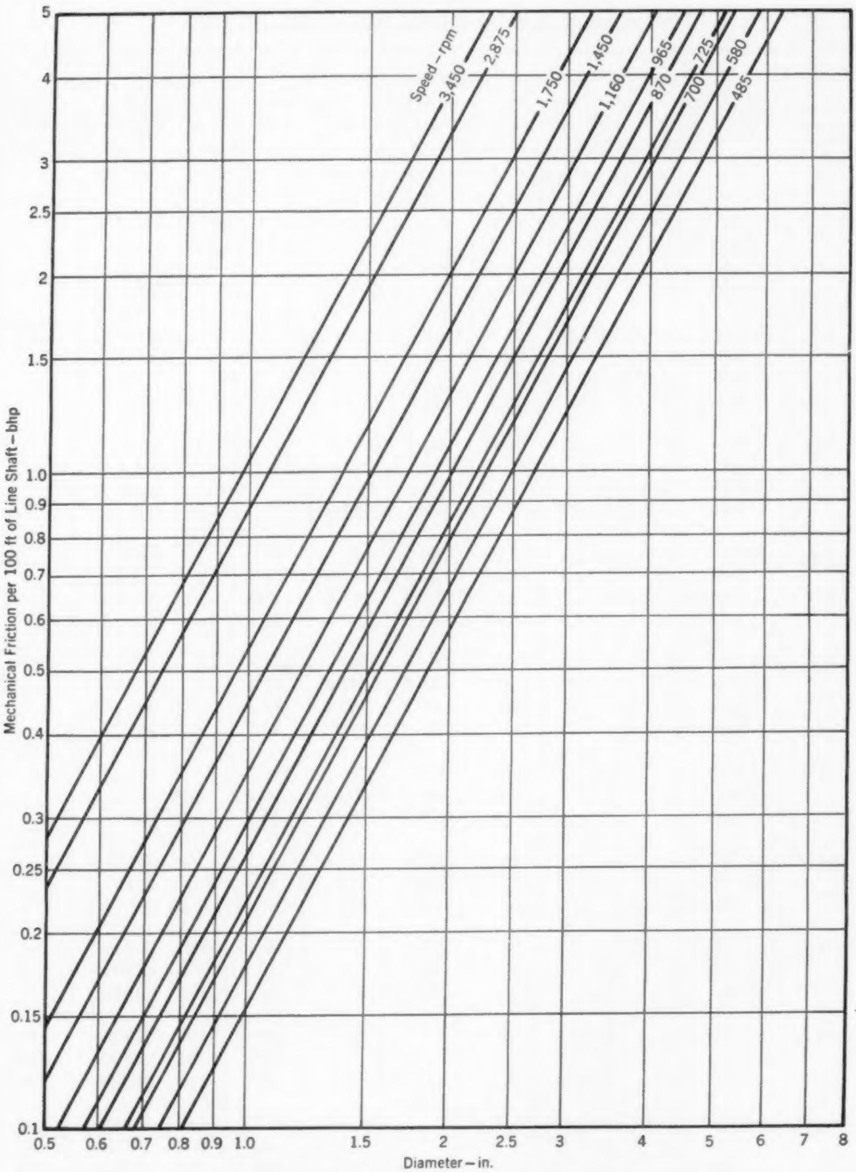


Fig. 5. Mechanical Friction in Line Shafts (See Note on Facing Page)

TABLE 4

Line Shaft Selection Chart for Type A Material *

Shaft Diameter *in.*	Speed *rpm*	Pump Thrust—*1,000 lb*								
		1	2	3	5	7.5	10	15	20	30
		Power Rating—*hp*								
3/4	3,500	22.8	21.7	18.6						
	1,760	11.4	10.9	9.3						
	1,160	7.5	7.2	6.2						
	860	5.6	5.3	4.6						
1	3,500	54.9	53.8	51.9	45.7					
	1,760	27.6	27.0	26.1	23.0					
	1,160	18.2	17.8	17.2	15.2					
	860	13.5	13.2	12.8	11.2					
1 3/16	3,500	97.2	96.5	95.0	90.0	79.8				
	1,760	48.8	48.5	47.7	45.2	40.1				
	1,160	32.2	32.0	31.5	29.8	26.4				
	860	23.9	23.7	23.4	22.1	19.6				
1 7/16	3,500		172	171	167	161	147			
	1,760		86.5	86.0	84.0	81.0	74.0			
	1,160		57.1	56.7	55.5	53.5	48.8			
	860		42.3	42.0	41.0	39.6	36.1			
1 1/2	3,500		196	194	191	183	174			
	1,760		98.5	97.9	96.0	92.0	87.4			
	1,160		65	64.5	63.2	60.6	57.6			
	860		48.1	47.8	46.9	45.0	42.7			
1 11/16	1,760			146	144	141	136	122		
	1,160			96.2	95.4	93.2	90.0	80.4		
	860			71.3	70.6	69.0	66.6	59.5		
1 15/16	1,760				228	225	221	209	191	
	1,160				150	148	145	138	126	
	860				111	110	108	102	93.5	
2 3/16	1,760				336	334	331	320	306	
	1,160				222	220	218	211	202	
	860				165	163	162	157	150	
2 7/16	1,760					473	469	461	448	410
	1,160					312	309	304	296	270
	860					231	229	226	220	200
2 11/16	1,760					620	617	611	598	564
	1,160					408	407	403	394	372
	860					303	302	299	293	276

* Steels with a minimum elastic limit of 23,300 psi and minimum ultimate tensile strength of 38,900 psi, such as SAE 1020.

TABLE 5

Line Shaft Selection Chart for Type B Material *

Shaft Diameter *in.*	Speed *rpm*	Pump Thrust—*1,000 lb*								
		1	2	3	5	7.5	10	15	20	30
		Power Rating—*hp*								
$\frac{3}{4}$	3,500	39.7	38.8	37.4	32.4					
	1,760	20.0	19.5	18.8	16.3					
	1,160	13.2	12.9	12.4	10.7					
	860	9.8	9.5	9.2	8.0					
1	3,500	94.5	93.8	93.0	89.5	82.5				
	1,760	47.5	47.2	46.7	45.0	41.5				
	1,160	31.3	31.1	30.8	29.7	27.3				
	860	23.2	23.1	22.9	22.0	20.3				
$1\frac{3}{16}$	3,500	167	167	166	163	157	149			
	1,760	84.0	84.0	83.5	82.0	79.0	75.0			
	1,160	55.4	55.4	55.0	54.1	52.1	49.4			
	860	41.0	41.0	40.7	40.0	38.6	36.6			
$1\frac{7}{16}$	3,500			296	294	289	283	264		
	1,760			149	146	145	142	133		
	1,160			98.3	97.6	96.0	94.0	87.6		
	860			72.7	72.3	71.0	69.5	64.8		
$1\frac{1}{2}$	3,500			336	334	330	324	306		
	1,760			169	168	166	163	154		
	1,160			111.2	110.7	109.2	107.2	101.4		
	860			82.6	82.1	81.1	79.6	75.2		
$1\frac{11}{16}$	1,760			252	251	248	246	239	227	
	1,160			166	165	164	162	157	150	
	860			123	122	121	120	117	111	
$1\frac{15}{16}$	1,760				393	392	390	382	373	345
	1,160				259	258	257	252	246	228
	860				192	192	191	187	182	169
$2\frac{3}{16}$	1,760				578	577	576	570	562	538
	1,160				382	381	380	376	371	355
	860				283	282	281	279	275	263
$2\frac{7}{16}$	1,760					816	815	810	802	781
	1,160					537	537	533	529	515
	860					398	398	395	392	381
$2\frac{11}{16}$	1,760						1,070	1,062	1,055	1,035
	1,160						703	700	696	682
	860						520	518	515	505

* Steels with a minimum elastic limit of 40,000 psi and a minimum ultimate tensile strength of 67,000 psi, such as American Iron & Steel Institute (AISI) C-1045.

used by individual manufacturers may affect the figures slightly.

Sec. A5.5—Line Shaft Selection

Line shaft selection shall be made in accordance with the following procedure, using Table 4 or 5, or should be calculated for the specific material used in accordance with Sec. 4.2.3.

5.5.1. Table 4 does not limit the maximum rotative speed of shafts, the maximum setting of shafts, or the bearing spacing used with the shafting.

5.5.2. Table 4 defines the maximum recommended horsepower for a given size of shaft, taking into account the effect of the hydraulic thrust of the pumping equipment and the weight of the shaft and suspended rotating parts. The table is applicable to any steel having a minimum elastic limit of 23,000 psi and a minimum ultimate tensile strength of 38,900 psi. Ratings listed in the table apply to steels purchased without specification of definite physical properties, such as SAE 1020.

5.5.3. Table 5 is similar to Table 4, except that it is applicable to a steel having a minimum elastic limit of 40,000 psi and a minimum ultimate tensile strength of 67,000 psi. Ratings listed in the table apply to AISI Type C-1045, annealed AISI Type 416 stainless steel, and others with similar physical properties.

5.5.4. Horsepower ratings shown in Tables 4 and 5 and calculated in accordance with Sec. 4.2.3 represent maximum loads and should not be increased by electric-motor service factors.

Section A6—Factory Inspection and Tests

Sec. A6.1—Performance Tests

6.1.1. The standard procedure for determining the performance of a vertical turbine pump by making a factory laboratory test of the bowl assembly and then calculating the anticipated field performance is described below. A performance test will be made only when specified in the purchaser's inquiry and order. The inquiry and order shall specify which of the following are required:

a. Standard running test
b. Witnessed running test
c. Shop inspection
d. Hydrostatic test of discharge head
e. Hydrostatic test of bowl assembly

If other tests are required, the purchaser shall describe them in detail.

6.1.2. The manufacturer shall notify the purchaser not less than 10 days prior to the date the pump or pumps will be ready for inspection or witness test.

Sec. A6.2—Standard Running Test

6.2.1. The pump bowl assembly will be operated from zero capacity to the maximum capacity shown on the performance curve submitted with the manufacturer's bid. Readings shall be taken at a minimum of five capacity points, including one point within ± 2 per cent of the design capacity specified on the request for bid.

The pump shall be operated at a speed within ± 5 per cent of the design speed. This does not apply to model or slow-speed tests described in Sec. 6.9.

6.2.2. At the conclusion of the test, three copies of the test data sheet and the anticipated field performance curve shall be supplied to the purchaser.

Sec. A6.3—Typical Laboratory Test Arrangement

Figure 6 shows a typical laboratory arrangement for the testing of a vertical turbine pump. A test laboratory will normally be constructed to provide favorable suction conditions for pump performance. If the purchaser plans to use the pump under questionable well or sump conditions and wishes the pump to be tested under these exact conditions, complete information should be included in the request for bid. If there is nothing stated in the bid with relation to required well or sump conditions, it shall be assumed that standard laboratory arrangements will be used.

Sec. A6.4—Capacity Measurement

The capacity of the pump shall be measured by means of a standard venturi tube, nozzle, orifice plate, or pitot tube traverse. The pump manufacturer shall supply evidence that the capacity-measuring device used has been properly calibrated, that it is in good condition, and that the pressure taps and piping are proper for the instrument being used and are essentially the same as during the calibration. Instruments which have not been calibrated should be geometrically similar to properly calibrated models.

A description of the application of fluid meters is contained in the ASME publication, "Fluid Meters—Their Theory and Application." A detailed description of the various meters and their application is given in Chapter B-2 of that publication, the physical constants and meter coefficients are indicated in Section C, and the discharge coefficient tolerances of the various meters are indicated in Chapter C-7.

The surface conditions, size, and length of the pipe preceding the fluid-measuring device are as important as the calibration of the device itself. Thus, piping should be in close conformity with that used when the instrument was calibrated or in accordance with the recommendations by the manufacturer of the fluid-measuring device.

Fluid manometers should be used for measuring the pressure differential across the meter.

Sec. A6.5—Head Measurement

All pump bowl assembly tests shall be made in open sumps, unless otherwise stated in the request for bid.

The pressure tap for head measurement shall be located in the discharge column not less than 2 ft above the pump bowl assembly. The pressure tap shall be at right angles to the pipe, free from burrs, and flush with the surface of the column pipe. The openings shall be of a diameter from $\frac{1}{8}$ to $\frac{1}{4}$ in. and of a length not less than twice the diameter.

As an alternative method, the pressure tap for head measurement can also be located not less than ten diameters downstream from the discharge elbow of the test pump. (The elbow to be furnished with the pump shall be used.) When the pump head is measured at this point, no deduction for elbow loss need be made in anticipating field performance.

For head measurements of 36 ft or less, only fluid manometers shall be used. For head measurements in excess of 36 ft, calibrated Bourdon or other gages with equivalent accuracy and reliability can be used. All gages shall be calibrated before and after each series of tests.

Sec. A6.6—Velocity Head

The average velocity in the pump column used to determine the velocity head shall be calculated from dimensions obtained by actual measurement of the pipe and shaft or enclosing-tube diameter at the point of pressure measurement.

If the pressure measurement is made downstream from the discharge elbow, the velocity head shall be obtained from actual measurement of the inside diameters of the discharge pipe at the point where the pressure tap is located.

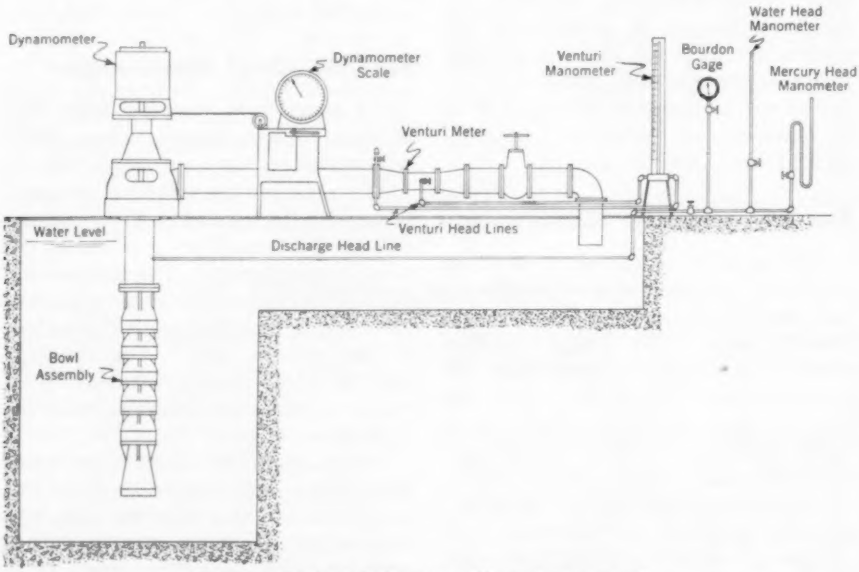


Fig. 6. Typical Laboratory Test Arrangement

Sec. A6.7—Horsepower Input

The power input to the pump shall be determined with a vertical dynamometer or a calibrated electric motor.

The torque of the dynamometer shall be measured by means of a calibrated springless scale, calibrated strain gage, or other device of equivalent accuracy.

Squirrel-cage induction motors (when operated at greater than half the nameplate rating), direct-current motors, synchronous motors, or wound-rotor induction motors with short-circuited secondary resistance may be employed for the determination of shaft input, provided the efficiencies or losses have been ascertained by an AIEE test or its equivalent.

Where the specifications call for an overall efficiency guarantee, the actual job motor can be used without calibration and the overall bowl assembly efficiency calculated directly.

Calibrated laboratory type electric meters and transformers shall be used to measure power input to all motors.

Sec. A6.8—Measurement of Speed

The rotating speed of the pump shall be obtained by a hand counter, electronic computer, or a stroboscope counting slip. It should be noted that

an accurate speed reading is important in determining power input when a dynamometer is used. Accuracy is less important when a calibrated motor is used.

Sec. A6.9—Large-Pump Tests

6.9.1. On all pump bowl assemblies where the horsepower is not in excess of 200 and the bowl diameter is not in excess of 20 in., the actual pump shall be tested in the manufacturer's laboratory.

6.9.2. If the horsepower exceeds 200, it shall be permissible for the manufacturer to test only the number of stages of the unit which come within this power requirement. If a test is made on a limited number of stages, no increase in efficiency shall be permitted for an increased number of stages when predicting the final performance of the complete bowl assembly. The head and horsepower shall be increased in direct proportion to the number of stages in the final assembly, compared with the number of stages used in the laboratory test.

6.9.3. When the size of the bowls exceeds 20-in. OD, a laboratory test on a model pump, homologous with the actual unit, may be used as a basis for the determination of the performance of the actual unit. (In general, when contract guarantees are to be based on model tests, the contract should specify model performance rather than inferred actual-unit performance. In the absence of this provision, allowance for the scale effect, if any, shall be agreed upon in writing by the representatives of both parties prior to the tests.)

The model pump shall be run at a speed sufficient to develop a head per stage at least equal to that of the actual unit, so that the velocities will equal or exceed those of the actual unit; or the manufacturer must submit evidence that a single-stage model does not cavitate under specified field suction conditions when operated at a speed such that the velocities will equal or exceed those of the actual unit.

6.9.4. On bowl assemblies which have an OD exceeding 20 in. or which require more than 200 hp, it will be permissible to test the actual bowl assembly at a speed slower than that at which the pump will run in the field rather than make a model test. No efficiency increase will be allowed when the performance in the slow-speed test is translated into that at full speed. The manufacturer must submit evidence that a single-stage bowl assembly or a single-stage model does not cavitate under specified field suction conditions when operated at a speed such that the velocities will equal or exceed those of the actual unit.

6.9.5. All large bowl assembly full-speed tests or model tests must be conducted with the identical submergence that will exist in the field, as shown on the request for bids.

Sec. A6.10—Hydrostatic Tests

6.10.1. A standard hydrostatic test on the pump bowl assembly shall be made at $1\frac{1}{2}$ times the shutoff head developed by the pump bowl assembly or at twice the rated head, whichever is greater.

6.10.2. A standard hydrostatic test on the discharge head shall be made at the pressure defined in Sec. 6.10.1, less the pump setting specified on the order.

Sec. A6.11—Recording and Computation of Test Results

6.11.1. All instrument test readings, as well as corrected readings, shall be recorded on the test sheet. Complete data concerning the pump,

driver, and instrument identification shall also be recorded.

6.11.2. All test results shall be translated into performance at the anticipated speed of the driver at the design point, by these formulas:

$$Q = Q_t \frac{N}{N_t}$$

$$H = H_t \left(\frac{N}{N_t}\right)^2$$

$$\text{bhp} = \text{bhp}_t \left(\frac{N}{N_t}\right)^3$$

in which Q is capacity (gpm), H is head (ft of water), bhp is brake horsepower, N is anticipated operating speed (rpm), and subscript "$_t$" indicates test values.

6.11.3. The bowl assembly input horsepower, when measured by a vertical dynamometer, is found from the expression KFN_t, in which K, the dynamometer constant, equals $\frac{2\pi L}{33{,}000}$, L is the length (ft) of the lever arm, F is the net force (lb) at the end of the lever arm, and N is the speed (rpm) of the driver when the test reading is taken.

6.11.4. The motor power input, in horsepower, is the corrected kilowatt input to motor divided by 0.746.

6.11.5. The bowl assembly input horsepower to a pump driven by an electric motor is:

$$\frac{\text{kw}}{0.746} E_g$$

kw being the corrected kilowatt input to motor and η_g the motor efficiency from the calibration curve.

6.11.6. The pump bowl assembly efficiency (E_l) is:

$$\frac{Qh_l}{3{,}960 \times (\text{bhp})}$$

in which Q is the measured capacity (gpm); h_l is the bowl assembly head (ft), including velocity head; and bhp is the brake horsepower to the pump bowl assembly, measured by dynamometer or calibrated motor.

6.11.7. The pump total head (H), in feet, is found by:

$$H = h_l - h_c - h_e$$

in which h_l is the bowl assembly head (ft), from test; h_c is the column loss (ft), obtained from Fig. 3 and based on complete pump setting; and h_e is the discharge head loss (ft), from Fig. 4 or actual test.

6.11.8. The pump input horsepower equals the bowl assembly input horsepower plus the line shaft loss in horsepower. The bowl assembly input horsepower is calculated from test, as in Sec. 6.11.3 or 6.11.5. The line shaft loss is obtained from Fig. 4 and based on complete pump setting.

6.11.9. The pump efficiency (E_p) is found by:

$$E_p = \frac{QH}{3{,}960 \times \text{pump input hp}}$$

in which the pump total head (H) is obtained from Sec. 6.11.7 and the power input from Sec. 6.11.8.

6.11.10. The overall efficiency (E) is the pump efficiency (E_p) multiplied by the motor efficiency (E_g).

6.11.11. The complete pump total head, efficiency, and pump input horsepower should be plotted as ordinates on the same sheet against the capacity as abscissa to show the anticipated field performance of the complete pumps.

Sec. A6.12—Other Tests

For more complete tests, or for tests involving fluids other than water, refer to the ASME "Power Test Code for Centrifugal and Rotary Pumps" as applicable.

ASA B58.1 (AWWA A101)

American Standard for

Vertical Turbine Pumps

Part B–Submersible Vertical Turbine Pumps

Section B1–Scope and Purpose

This standard is recommended as a guide for users of the submersible vertical turbine pump in selecting new equipment. It applies to pumps using a $7\frac{1}{2}$-hp motor or larger. The suggested standards are to be considered a minimum requirement for a first-quality vertical turbine pump, but do not preclude the use of more elaborate specifications on the part of either user or manufacturer, nor is it intended to restrict the use of any equipment not meeting the requirements of this standard should the user not consider such compliance necessary.

This standard is applicable primarily to pumps that are constructed of accepted standard materials of the best quality and workmanship, and that handle cold, clear water, usually from an underground well.

Section B2–Definitions

In addition to the definitions given below, Sec. 2.3–2.12 and Sec. 2.14–2.17 of Part A (line shaft pumps) also apply to submersible pumps.

B2.1. *A submersible pump* is an integral combination of a vertical turbine pump, close coupled to an electric motor designed for sustained and continuous operation under water. The unit is suspended from a surface plate by the vertical discharge pipe and receives electrical energy through a submersible power cable. This type of pump has no line shaft, or shaft-enclosing tube. A basic pump consists of seven elements, defined as follows:

B2.1.1. *The pump bowl assembly* is a single or multistage, centrifugal or mixed-flow vertical pump with discharge coaxial with the shaft. It can have open, semiopen, or enclosed impellers.

B2.1.2. *The vertical discharge pipe* conducts water from the pump bowl assembly to the surface plate connection. It supports the pump and driver in the well and an electric cable, which carries current from the surface to the motor lead connection.

B2.1.3. *The head assembly* consists of a surface plate from which the vertical discharge pipe is suspended, contains provisions for the cable to pass through, and may include an elbow which directs the water into a piping system as required.

B2.1.4. *The driver* is a squirrel cage induction electric motor suspended below the interconnector at the bottom of the bowl assembly; it contains a bearing capable of carrying the pump hydraulic-thrust load and the weight of all rotating parts.

TABLE 6

Standard Nomenclature

Part No.	Name of Part	Typical Material	Function of Part
101	Top bowl flange	Cast iron	Connects pump to discharge pipe
102	Top or discharge bowl	Cast iron	Guides flow to discharge pipe
32	Pump shaft	Stainless steel	Transmits power to impellers
34	Top bowl bearing	Bronze or rubber	Guides top end of pump shaft
35	Intermediate bowl bearing	Bronze or rubber	Guides shaft at impellers
36	Intermediate bowl	Cast iron	Directs flow from impeller to next impeller above
42	Strainer	Galvanized steel or bronze	Prevents large objects from entering pump
38	Impeller	Bronze or cast iron	Imparts energy to water
39	Impeller lock collet	Steel	Locks impeller to shaft
40	Suction case	Cast iron	Directs water to first-stage impeller
110	Sand collar	Bronze	Restricts sand from entering bearing
111	Upper strainer interconnector bearing	Bronze	Guides lower end of pump shaft
112	Strainer interconnector	Cast iron	Connects suction bowl to interconnector and supports strainer
113	Lower strainer interconnector bearing	Bronze	Guides lower end of pump shaft
114	Interconnector	Cast iron	Connects strainer interconnector to motor; has splits or pocket to allow coupling connection
115	Pump-motor coupling	Stainless steel	Connects pump shaft to motor shaft
116	Welding discharge elbow	Steel	Connects vertical discharge pipe to discharge pipeline
117	Flanged discharge elbow	Cast iron	Connects vertical discharge pipe to discharge pipeline
118	Cable	Copper with synthetic-rubber or plastic insulation and protective jacket	Conducts electricity to motor
119	Cable clamp	Stainless steel or rubber	Fastens cable to column pipe
120	Motor cable splice (mechanical)	Metal or plastic	Joins motor leads with power cable
121	Discharge pipe coupling	Steel	Connects discharge pipe sections
122	Discharge pipe	Steel	Conducts water out of well
123	Conductor guard	Bronze or steel	Protects conductor
124	Cable terminal	Various	Secures motor cable into motor case
125	Submersible motor	Various	Drives pump
126	Suction interconnector bearing	Bronze or rubber	Guides lower end of pump shaft
127	Surface plate	Steel or cast iron	Supports pump, motor, and discharge pipe
128	Surface plate (sealed)	Steel or cast iron	Supports pump, motor, and discharge pipe and seals off well from contamination

TABLE 6—*Standard Nomenclature (contd.)*

Part No.	Name of Part	Typical Material	Function of Part
129	Surface plate gasket	Rubber or asbestos compound	Seals surface plate and well flange
130	Well flange	Steel or cast iron	Base plate to assure pump alignment and seal well casing
131	Cable seal gland	Bronze	Supports cable and seals between cable and surface plate
132	Terminal box	Cast iron	Provides enclosured means of connecting cable and surface wiring
133	Access hole plug	Steel	Provides access to well
134	Well vent connection	Steel	Makes provision for air vent for well
135	Suction intercon-nector	Cast iron	Connects motor to bottom intermediate bowl, acts as suction bowl, and supports strainer

B2.1.5. *The cable* is the conductor that conducts power from the surface to the motor terminal leads.

B2.1.6. *The splice* is the waterproof device connecting the power cable and the electric-motor leads or joining the cable below the surface.

B2.1.7. *The motor leads* conduct electricity between the cable and the motor windings.

Section B3—Nomenclature

Sec. B3.1—Standard Nomenclature

Table 6 lists the name of the part, together with its function and typical material. The material listed is intended to be typical only and does not constitute a recommendation. The part numbers refer to the numbers in Fig. 7 and 8.

Sec. B3.2—Order Form

A recommended specification form for use in purchasing vertical turbine pumps is given in Table 2.

Section B4—General Specifications

Sec. B4.1—General

B4.1.1. *Descriptive matter.* The bidder shall submit, with his proposal, sufficient descriptive material or outline drawings to demonstrate compliance with these specifications, and a performance curve showing pump total head, pump input horsepower, and pump efficiency over the specified head range for the installed pump.

B4.1.2. *Sanitary codes.* The pump shall conform to the sanitary codes governing the installation. The purchaser shall furnish, as a part of these specifications, all information necessary for the construction of the pump to meet these requirements.

Sec. B4.2—Submersible Motor

B4.2.1. *Materials.* Construction materials shall be suitable for their application from the standpoints of corrosion resistance and mechanical performance.

B4.2.2. *Design.* The motor shall be of the squirrel cage induction type, suitable for across-the-line starting and shall be capable of reduced-voltage starting. It shall be capable of continuous operation under water at the conditions specified.

B4.2.3. *Temperature.* The motor temperature rise shall conform to the latest NEMA standards for submersible motors.

B4.2.4. *Thrust bearing.* A thrust bearing of ample capacity to carry the weight of all rotating parts plus the hydraulic thrust shall be an integral part of the driver. The bearing shall be of such a size that the average life rating is based on 5 years' continuous operation. It shall also have ample capacity to permit the pump to operate for short periods with the discharge valve closed.

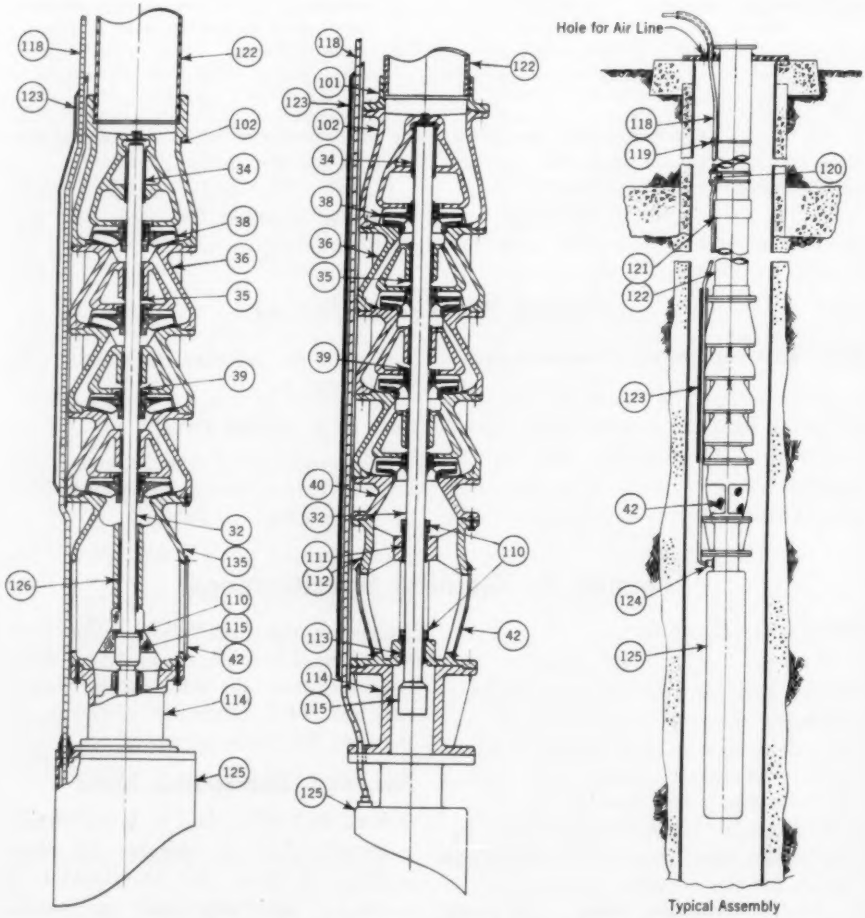


Fig. 7. Typical Submersible-Pump Assembly (Bowl Assemblies)

B4.2.5. *Foreign matter.* Suitable precautions shall be taken to restrict sand, silt, or foreign material from entering the motor.

B4.2.6. *Diameter.* The maximum motor diameter and the minimum inside diameter of the well shall be in such relationship that the maximum water velocity past the motor shall be 12 fps. For this purpose a minor irregularity in the motor shape, such as that caused by the cable connection, shall not be included in the motor diameter measurement.

Sec. B4.3—Submersible Cable

B4.3.1. *Conductors.* The cable shall be comprised of three or more separate conductors or a single cable assembly with three or more conductors. Stranding shall meet ASTM class designation standards *—Class B on No.

* The ASTM class designations referred to above are as follows:

Class B on No. 10 and smaller cable provides for at least 7 strands minimum.

Class C on No. 9 through No. 2 cables provides for at least 19 strands minimum.

Class C on No. 1 through 4/0 cable provides for at least 37 strands minimum.

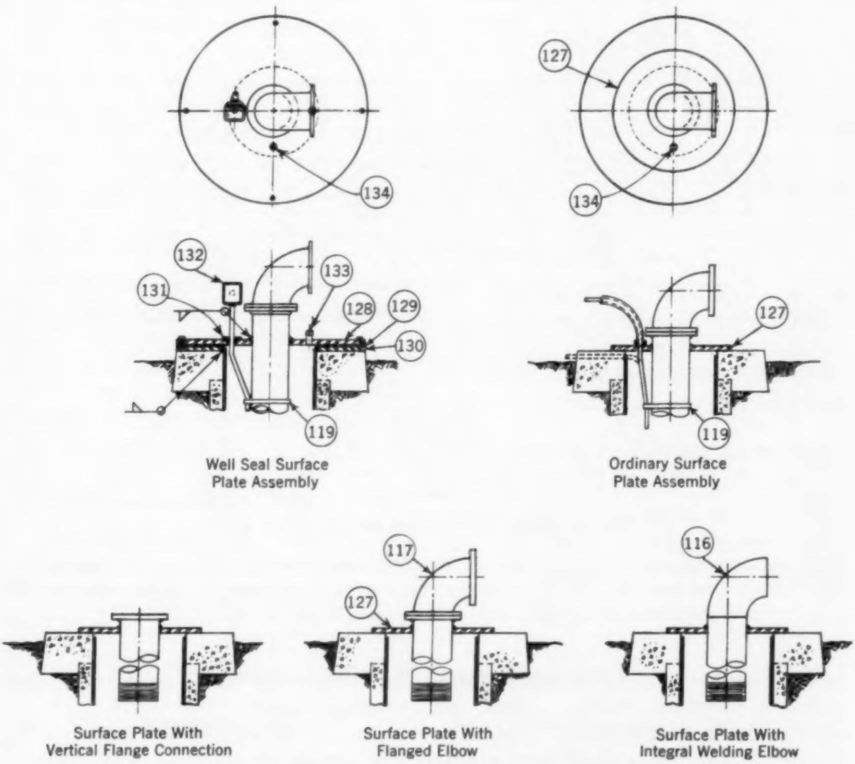


Fig. 8. Submersible-Pump Discharge Styles and Surface Plate Assemblies

Well seal surface plates are for use where well sealing is required; a flange must be welded to the casing by a continuous watertight weld or the plate must be grouted in place. Ordinary surface plates may be used where sanitary well seals are not required.

10 and smaller cable and Class C on No. 9 and larger cable. Each conductor shall be insulated by synthetic rubber or plastic insulation suitable for continuous immersion in water. When three or more single conductors are used, each must be jacketed. When a three or more conductor cable is used, it must be jacketed. The (IPCEA) code for operation in air. (The connecting electric cable from the starting equipment to the surface plate shall meet the National Electrical Code or local codes, whichever may govern.)

B4.3.2. *Supports.* The cable shall be suitably supported from the column at a number of points adequate for the

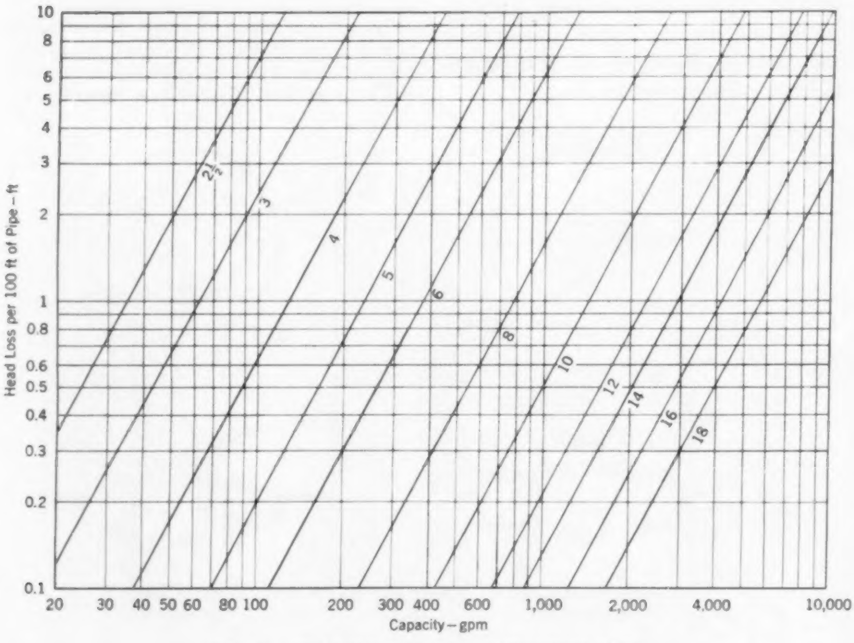


Fig. 9. Head Loss Chart for Standard Pipe

Diagonals are labeled to show nominal diameters (in inches) of discharge column pipe. The calculations used in constructing the chart were based on inside diameters, which are close to the nominal sizes (for example, 10 in. = 10.12 in ID).

jacket material must be oil- and water-resistant synthetic rubber, metal, or other suitable mechanically protective material. The cable shall have a sufficient conductor area to meet the minimum requirement of the Insulated Power Cable Engineers Assn. type of cable used with corrosion-resistant clamps.

B4.3.3. *Fittings.* All cable fittings and terminals shall be watertight at the pressure encountered in use.

B4.3.4. *Lengths.* For each 50 ft of setting 1 ft of extra cable shall be al-

lowed to compensate for possible twist or sag of the cable during installation; 10 ft shall be provided beyond the surface plate.

B4.3.5. *Shielding.* The electrical conductors shall be protected by a corrosion-resistant shield where they pass the pump bowls.

Sec. B4.4—Surface Plate

The surface plate (pump base) shall be rigid enough to support the entire weight of the suspended parts when filled with water. The plate shall provide suitable openings for the power cable, well vent, and water level indicator as required. The plate shall also support the discharge connection furnished in a size adequate for the required flow rate and in a pressure series consistent with the surface pressure to be delivered by the pump.

Sec. B4.5—Strainer

A strainer, if furnished, shall have a net inlet area equal to at least three times the impeller inlet area. The maximum unit opening shall not be more than 75 per cent of the minimum opening of the water passage through the bowl or impeller.

Sec. B4.6—Discharge Pipe

The discharge pipe may be furnished in random lengths connected by threaded sleeve couplings. For settings up to 500 ft, the minimum weight shall conform to the values shown in Table 3, and shall have ASA standard tapered pipe threads. For pumps with a total head in excess of 500 ft, each application shall be checked to determine that the strengths of the pipe and threaded joints are adequate. The size shall be such that velocities are not less than 4–5 fps, nor more than 15 fps.

Sec. B4.7—Pump Bowls

Pump bowl castings shall be free of blow holes, sand holes, and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the head at rated capacity or 1½ times the shutoff head, whichever is greater. The bowls may be equipped with replaceable seal rings on the suction side of enclosed impellers.

Sec. B4.8—Impellers

The impellers shall be of the open, semiopen, or enclosed type, statically balanced. They shall be securely fastened to the impeller shaft with keys, taper bushings, locknuts, or setscrews.

Sec. B4.9—Pump-Motor Coupling

The pump-motor coupling shall be of a noncorrosive material and shall be capable of transmitting the total torque and total thrust of the unit in either direction.

Section B5—Engineering Data

Sec. B5.1—Discharge Pipe

Diameters and weights of standard discharge pipe sizes are given in Table 3.

Sec. B5.2—Discharge Friction Loss

The discharge pipe friction loss chart (Fig. 9 or 10) should be used to determine the loss in head due to friction.

Sec. B5.3—Discharge Elbow Head Loss

The discharge elbow head loss chart (Fig. 10) should be used to determine the hydraulic losses in the discharge elbow. Where extreme accuracy is imperative, actual loss measurements in the discharge elbow to be used—with the correct discharge pipe—should be specified on the bid request by the purchaser.

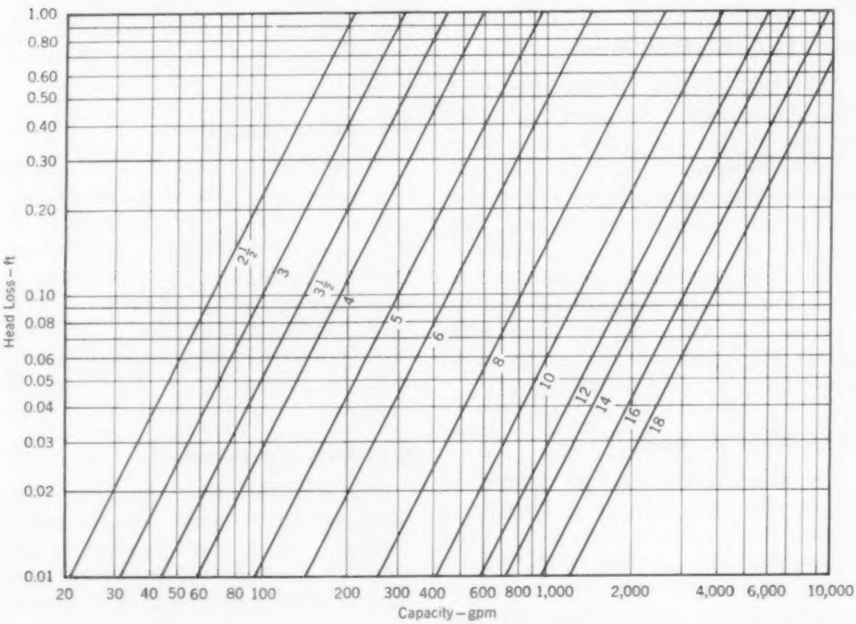


Fig. 10. Head Loss Chart for 90-deg Elbow

Diagonals are labeled to show nominal diameters (in inches) of discharge elbow pipe. The calculations used in constructing the chart were based on inside diameters, which are close to the nominal sizes (for example, 10 in. = 10.12 in. ID).

Section B6—Factory Inspection and Tests

Sec. B6.1—Performance Tests

B6.1.1. The standard procedure for determining the performance of a vertical turbine pump—by making a factory laboratory test of the bowl assembly and then calculating the anticipated field performance—is described below. A performance test will be made only when specified in the purchaser's inquiry and order. The inquiry and order shall specify which of the following are required:

a. Standard running test
b. Witnessed running test
c. Shop inspection
d. Hydrostatic test of bowl assembly.

If other tests are required, the purchaser shall describe them in detail.

B6.1.2. The manufacturer shall notify the purchaser not less than 10 days prior to the date the pump or pumps will be ready for inspection or witness test.

Sec. B6.2—Standard Running Test

B6.2.1. The pump bowl assembly will be operated from zero capacity to the maximum capacity shown on the performance curve submitted with the manufacturer's bid. Readings shall be taken at a minimum of five capacity points, including one point within ± 2 per cent of the design capacity specified on the request for bid.

B6.2.2. At the conclusion of the test, three copies of the test data sheet and the anticipated field performance curve shall be supplied to the purchaser.

Sec. B6.3—Typical Laboratory Test Arrangement

Figure 11 shows a typical laboratory arrangement for the testing of a vertical turbine pump. A test laboratory will normally be constructed to provide favorable suction conditions for pump performance. If the purchaser plans to use the pump under questionable well or sump conditions and wishes the pump to be tested under these exact conditions, complete information should be included in the request for bid. If there is nothing stated in the bid with relation to required well or sump conditions, it shall be assumed that standard laboratory arrangements will be used.

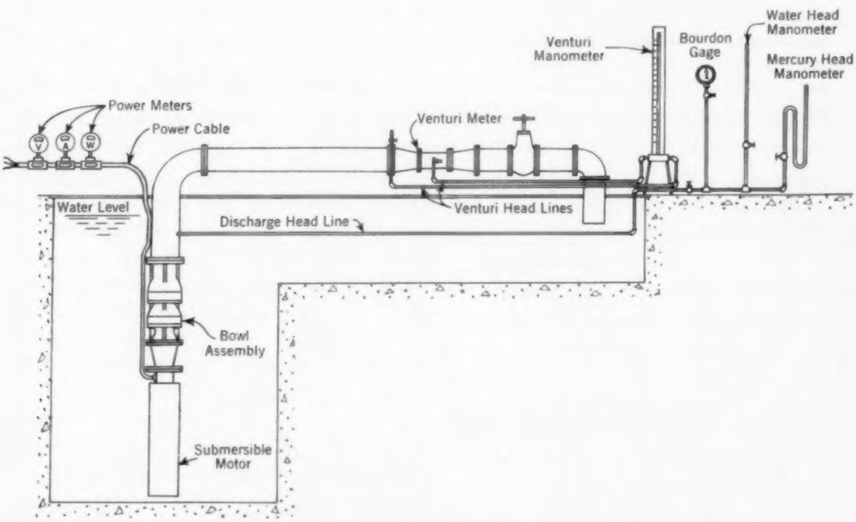


Fig. 11. Typical Laboratory Test Arrangement

Sec. B6.4—Capacity Measurement

The capacity of the pump shall be measured by means of a standard ven-

turi tube, nozzle, orifice plate, or pitot tube traverse. The pump manufacturer shall supply evidence that the capacity-measuring device used has been properly calibrated, that it is in good condition, and that the pressure taps and piping are proper for the instrument being used and are essentially the same as during the calibration. Instruments which have not been calibrated should be geometrically similar to properly calibrated models.

A description of the application of fluid meters is contained in the ASME publication, "Fluid Meters—Their Theory and Application." A detailed description of the various meters and their application is given in Chapter B-2 of that publication, the physical constants and meter coefficients are in-

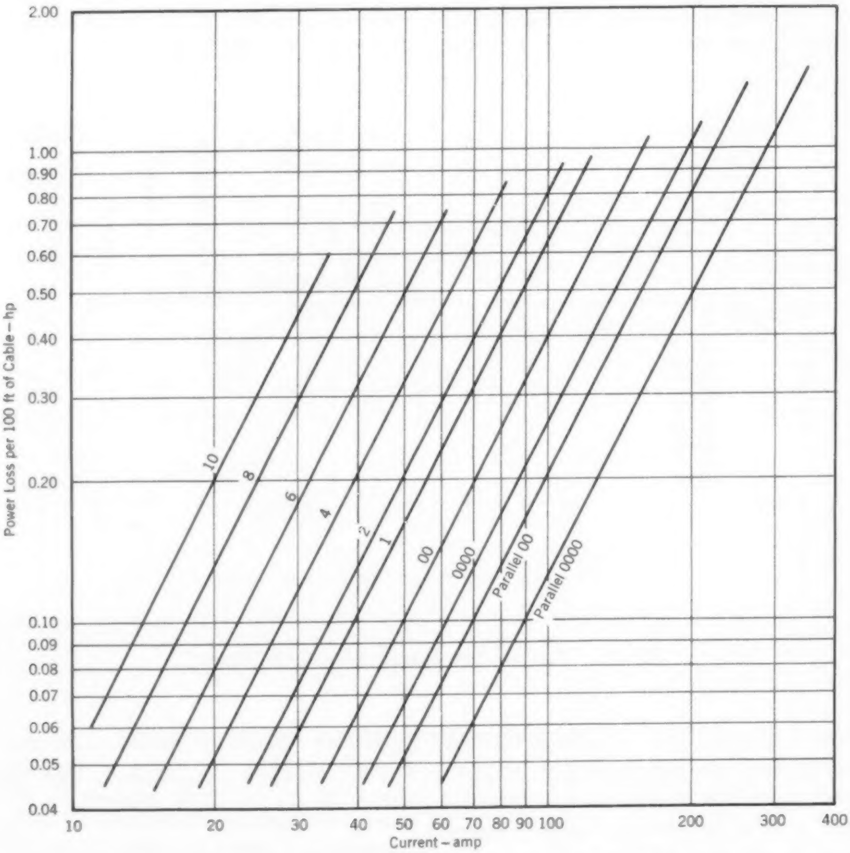


Fig. 12. Power Loss Chart for Three-Conductor Copper Cable

Diagonals are labeled to show sizes (American Wire Gage) of cable conductor wire, and are based on a copper temperature of 60°C and an ambient air temperature of 30°C. Current should not exceed the plotted maximum on any given line. Maximum values must be reduced by a factor of 0.82 for an air temperature of 40°C.

dicated in Section C, and the discharge coefficient tolerance of the various meters are indicated in Chapter C-7.

The surface conditions, size, and length of the pipe preceding the fluid-measuring device are as important as the calibration of the device itself. Thus, piping should be in close conformity with that used when the instrument was calibrated or in accordance with the recommendations by the manufacturer of the fluid-measuring device.

Fluid manometers should be used for measuring the pressure differential across the meter.

Sec. B6.5—Head Measurement

All pump bowl assembly tests shall be made in open sumps, unless otherwise stated in the request for bid.

The pressure tap for head measurement shall be located in the discharge pipe not less than 2 ft above the pump bowl assembly. The pressure tap shall be at right angles to the pipe, free from burrs, and flush with the surface of the discharge pipe. The openings shall be of a diameter from $\frac{1}{8}$ to $\frac{1}{4}$ in. and of a length not less than twice the diameter.

As an alternative method, the pressure tap for head measurement can also be located not less than ten diameters downstream from the discharge elbow of the test pump. (The elbow to be furnished with the pump shall be used.) When the pump head is measured at this point, no deduction for elbow loss need be made in anticipating field performance.

For head measurements of 36 ft or less, only fluid manometers shall be used. For head measurements in excess of 36 ft, calibrated Bourdon or other gages with equivalent accuracy and reliability can be used. All gages shall be calibrated before and after each series of tests.

Sec. B6.6—Velocity Head

The average velocity in the pump column used to determine the velocity head shall be calculated from dimensions obtained by actual measurement of the pipe diameter at the point of pressure measurement.

If the pressure measurement is made downstream from the discharge elbow, the velocity head shall be obtained from actual measurement of the inside diameters of the discharge pipe at the point where the pressure tap is located.

Sec. B6.7—Power Input to Pump Motor

The actual job motor shall be used and the overall submersible-pump efficiency shall be calculated from the measured power input.

Calibrated laboratory type electric meters and transformers shall be used to measure the power input to all motors.

Sec. B6.8—Large-Pump Tests

Sec. A6.9 of Part A (line shaft pumps) of this standard shall also apply to submersible pumps.

Sec. B6.9—Hydrostatic Tests

A standard hydrostatic test on the pump bowl assembly shall be made at $1\frac{1}{2}$ times the shutoff head developed by the pump bowl assembly, or at twice the rated head, whichever is greater.

Sec. B6.10—Recording and Computation of Test Results

B6.10.1. All instrument test readings, as well as corrected readings,

shall be recorded on the test sheet. Complete data concerning the pump, driver, and instrument identification shall also be recorded.

B6.10.2. All test results shall be translated into performance at the anticipated speed of the driver at the design point, according to the following formulas:

$$Q = Q_t \frac{N}{N_t}$$

$$H = H_t \left(\frac{N}{N_t}\right)^2$$

$$\text{bhp} = \text{bhp}_t \left(\frac{N}{N_t}\right)^3$$

in which Q is capacity (gpm), H is head (ft of water), bhp is brake horsepower, N is anticipated operating speed (rpm), and subscript "$_t$" indicates test values.

B6.10.3. The motor power input, in horsepower, is the corrected kilowatt input to motor divided by 0.746.

B6.10.4. The bowl assembly input horsepower to a pump driven by an electric motor is:

$$\frac{\text{kw}}{0.746} E_g$$

kw being the corrected kilowatt input to motor and E_g the motor efficiency from the calibration curve.

B6.10.5. The pump bowl assembly efficiency (E_l) is:

$$\frac{Qh_l}{3{,}960 \times (\text{bhp})}$$

in which Q is the measured capacity (gpm); h_l is the bowl assembly head (ft), including velocity head; and bhp is the brake horsepower to the pump bowl assembly.

B6.10.6. The pump total head (H), in feet, is found by:

$$H = h_l - h_c - h_e$$

in which h_l is the bowl assembly head (ft), from test; h_c is the discharge loss (ft), obtained from Fig. 9 or 10 and based on complete pump setting; and h_e is the discharge elbow loss (ft), from Fig. 10 or actual test.

B6.10.7. The pump input horsepower equals the bowl assembly input plus the cable loss (obtained from Fig. 12) from the surface plate to the motor.

B6.10.8. The overall submersible-pump efficiency (E_p) is found by:

$$E_p = \frac{QH}{3{,}960 \times \text{input hp to motor}}$$

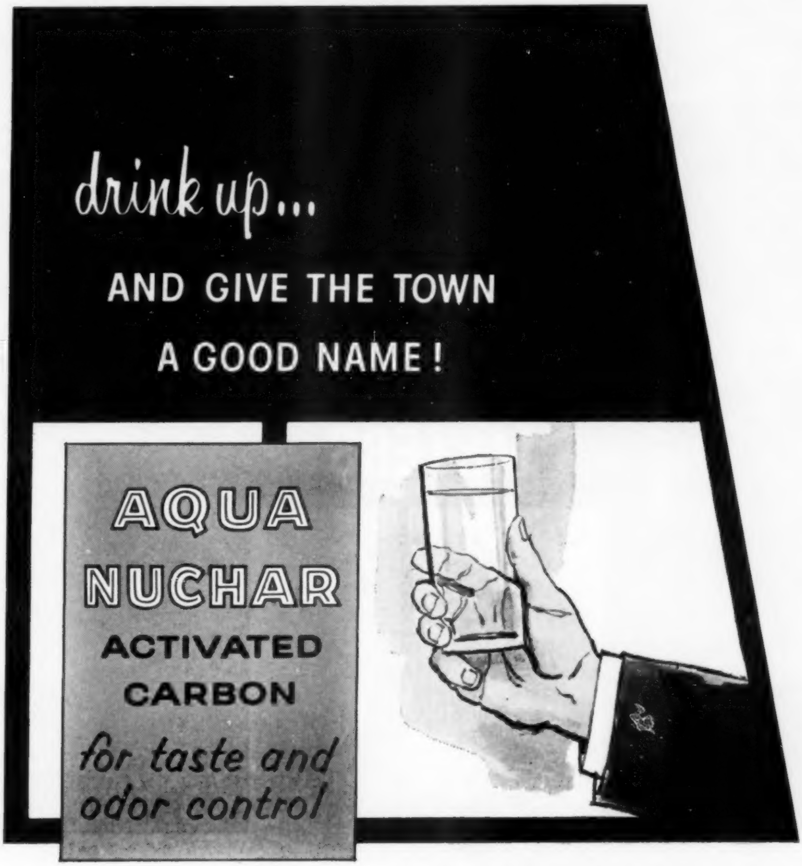
in which the pump total head (H) is obtained from Sec. B6.10.6 and the power input from Sec. B6.10.7.

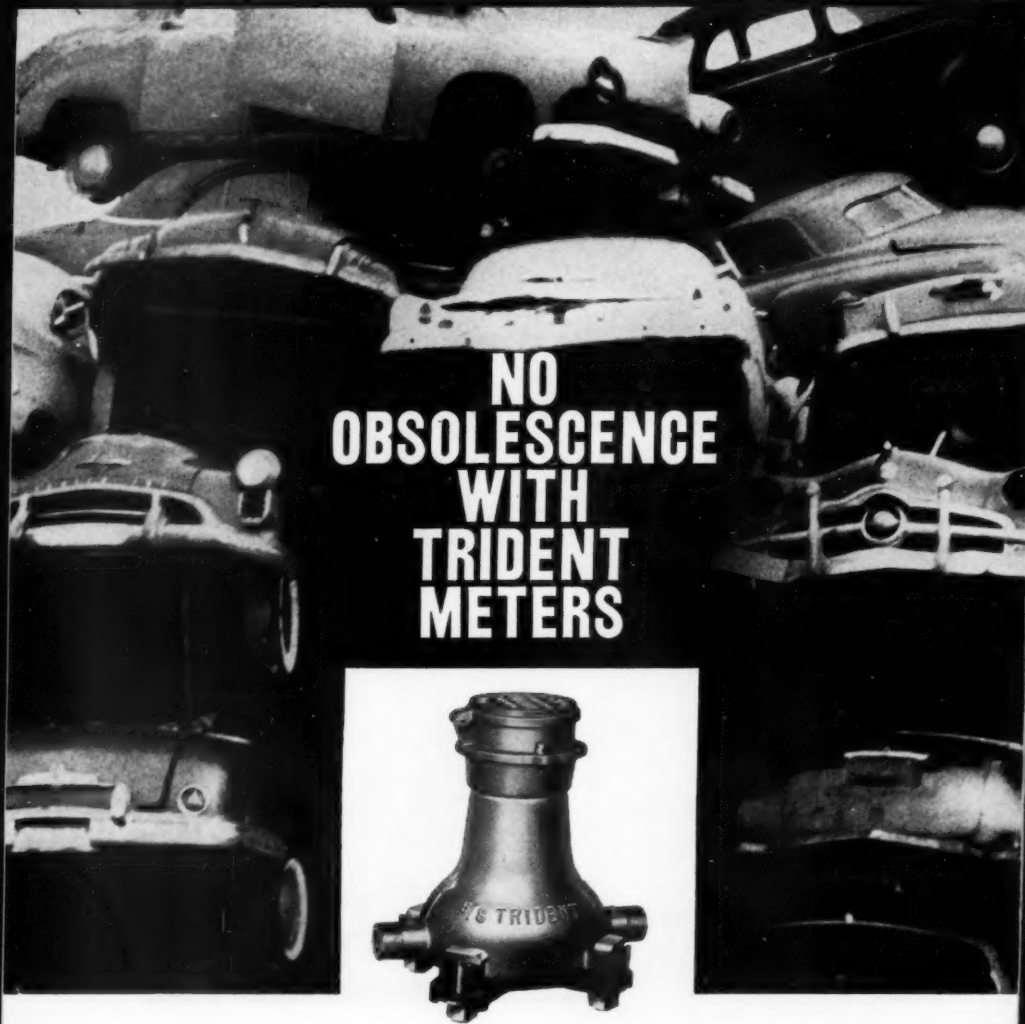
B6.10.9. The overall efficiency (E) is the pump efficiency (E_p) multiplied by the motor efficiency (E_g).

B6.10.10. The complete pump total head, overall efficiency, and input horsepower should be plotted as ordinates on the same sheet against the capacity as abscissa to show the anticipated field performance of the complete pumps.

Sec. B6.11—Other Tests

For more complete tests, or for tests involving fluids other than water, refer to the ASME "Power Test Code for Centrifugal and Rotary Pumps" as applicable.


drink up...
AND GIVE THE TOWN
A GOOD NAME!
AQUA
NUCHAR
ACTIVATED
CARBON
for taste and
odor control



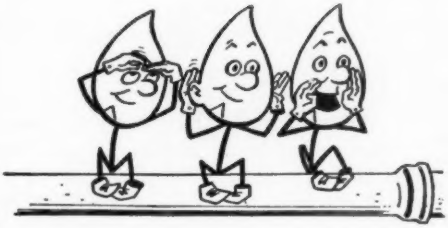
Being modern is the continuous process of going out-of-date tomorrow. Look at the record of Trident design improvements and you'll find this statement is just as true of water meters as it is of automobiles . . . *with one exception*. ■ With Trident meters, your department is probably the only service in your community equipped with *built-in modernization* . . . a process which eliminates the high cost of obsolescence. ■ Here's how it works. ■ Every time you replace work-worn parts in a Trident disc meter, you automatically use *modern* parts identical to those in the *latest* model . . . parts embodying every thoroughly tested advancement known to the science of metering. ■ *All of the many design improvements now on our drawing boards continue this long standing Neptune policy.*

neptune

TRIDENT WATER METERS

NEPTUNE METER COMPANY ■ LIQUID METER DIVISION

47-25 34th St., Long Island City 1, N. Y./Neptune Meters, Ltd., 1430 Lakeshore Rd., Toronto 14, Ont.
Offices in Principal Cities



Percolation and Runoff

An overdose of desalts seems to be disturbing the water industry these days, with everyone up to and including President Kennedy seeing in the sea the solution to all our problems. What they have failed to understand —no doubt as a result of our own silence—is that most "water shortages" are shortages not of water at all, but of the facilities to collect or distribute it. Thus, though the widespread attention and concern have been most welcome, they have been somewhat frustrating as well, rather like having a physician concern himself with our malnutrition while we're dying of ileitis. And even though we recognize that first things can't always be first, even though we convince ourself that a flank attack is better than no attack at all, even though we appreciate that the "breakthrough" in desalinization will be a most notable achievement, we can't help but add up the money, time, and effort of an unnecessary crash program in terms of present plant deficiencies in the nation's water systems.

The presently authorized program of the Office of Saline Water is certainly a worth-while one, more in its stimulation of research and development than in its financial support of it. Without question, too, activities under this program will hasten the achievement of a "breakthrough" in desalting sea water. But what concerns us is the delusion that such a "breakthrough" will "solve" the water problem. It certainly wouldn't have solved the "shortage" in Boston last June, when water use had to be curtailed although the reservoirs were overflowing. It certainly wouldn't have solved the "shortage" in Detroit last summer, when water supply to outlying areas was seriously restricted despite a riverful of fresh water at the utility's intake. And it certainly wouldn't solve similar shortages in thousands of communities throughout the country every year. What it would do is make the sea a considerably more feasible alternative source of supply than it now is.

Fostering the delusion that we must start sea-sucking soon are such "authoritative" statements as that recently issued by the House of Representatives Science and Astronautics Committee, indicating that, although the nation in 1940 had 109 bgd more water than it was using, by 1960 "the situation was reversed and the rate of use surpassed dependable supplies by 8 bgd." Or the announcement by Dr. A. L. Miller of the Office of Saline Water that: "Within 20 years we may be short as

(*Continued on page 36 P&R*)

(*Continued from page 35 P&R*)

much as 85 bgd," present demands being estimated at 312 bgd of a total of 515 bgd available. Or similarly frightening "facts" by other authorities, pointing out, for instance, that "the current estimate of usable fresh water in lakes, streams, and reservoirs is 500 bil gal. Thus, shortly we will be in an exact, delicate balance between supply and demand." The public "appeal" of such statements, contrasted to the kind Dr. Richard D. Hoak of Mellon Institute made at a recent TAPPI meeting probably explain in good part the presently prescribed "overdose." After all, even though he is undoubtedly correct in estimating present consumptive use as 72 bgd of a potential 650 bgd, Dick Hoak could hardly expect to excite anyone to action with a statement that "America has no cause to worry about a water shortage—either now or in the year 2000."

If money and effort really have to be scared out of the public, perhaps the industry will have to learn to play up its deficiencies instead of trying to do its best despite them. It could certainly apply pressure by reducing pressure. And it could no doubt dream up some appropriately irresponsible statements relating the incidence of heart disease or cancer to the deficiency in water distribution facilities or to the inadequacy of rates or, even, to the insufficiency of personnel compensation in the field. More effectively, though, as well as more in character, water utilities can take advantage of the attention aroused by the desalters to educate their own publics in the facts of their local situations. After all, if people really believe that the nation is just about out of water, they certainly ought to be interested in your plans to guarantee an adequate supply for the future—your antidote for that overdose.

Accentuating the positive, meanwhile, are Michigan, Ohio, and the Atlantic Coast Line Railroad:

"Michigan Is Water Unlimited" is the word that is being spread in a series of advertisements published as a public service by the state's newspapers in cooperation with the Michigan Press Association and the Michigan Economic Development Department. "Michigan," according to the ads, "with its 11,000 inland lakes and 36,000 miles of streams," not to mention vast underground reserves, "is first in water resources—today, tomorrow, and for the whole foreseeable future." Suggesting that Michiganders clip the ads and send them to friends in other states, just as Michigan autoists carry the "Water Wonderland" caption far and wide on their license plates, the sponsors of the campaign point to their slogan "Michigan Means Business" as an explanation of the state's appreciation of the importance of water to its growth and well-being.

Ohio, meanwhile, with industrial use already greater than that of any other state in the nation, is also clamoring for still more users. One of the loudest clamors so far was a 40-page Sunday supplement in the New York *Times* of Nov. 13, 1960, in which the state boasted of an "ample water supply," well managed by the new Ohio Water Commission and capable of almost unlimited expansion.

And the Atlantic Coast Line Railroad, site-selling along its route, recently pinpointed the Flint River area, between Albany and Camilla in south-

(*Continued on page 38 P&R*)

(*Continued from page 36 P&R*)

west Georgia, as still another water-blessed region offering industry what it needs most—plus, of course, convenient mainline service.

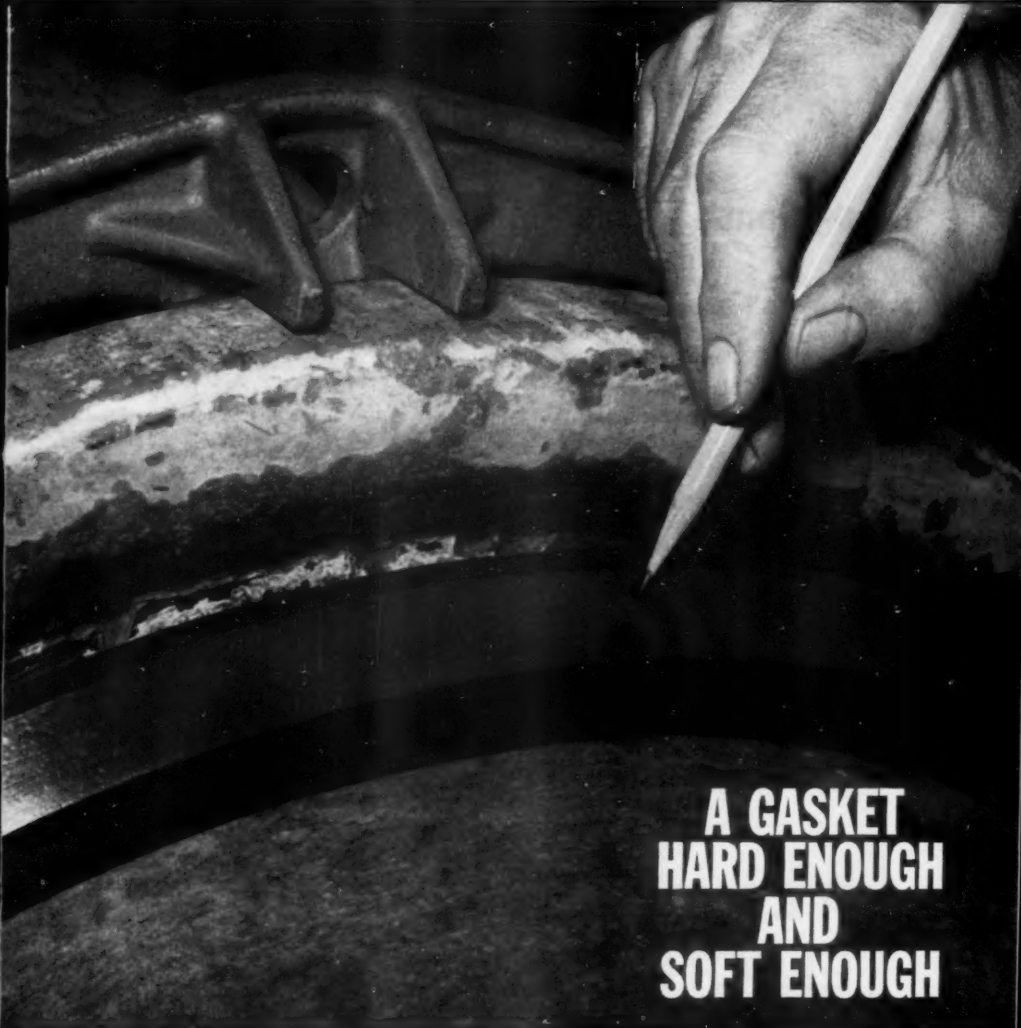
All of which seems to be harking back to a rather primitive Mahomet-and-the-mountain concept. But did we hear someone say "all the water you need" at least *when* you need it?

The inside story of the annual meeting of the AWWA Board of Directors, held Jan. 22–24 at the Park-Sheraton Hotel in New York, will probably never be told. A purportedly "full" report of the meeting will appear in the March issue of *Willing Water,* but we doubt if that even mentions the Kennedian greeting of 18 in. of snow and zero temperatures arranged for the directors. It won't mention either that Lauren Grayson, past-president from Glendale, Calif., detoured here via Boston, ostensibly because of the storm rather than his taste for bus riding. It will probably say nothing about the Caeserean birthday cake (cut in half) of the present of snowshoes and earmuffs provided in celebration of his sometennial as a Wertz. Nor about the Merryfieldian birthday cake (the other half) nor his present of a space helmet to preserve him regardless of how far his Advancement Committee decides to go. Nor even about the Cramerian wedding anniversary celebrated by the gift of a two-ended scepter to John and Henrietta in recognition of who was nominated and who will be boss of AWWA in the coming year. It will probably not bring up the blankety-blanketing of hot-blooded Jess Haley zeroing in at the Executive Committee meeting, the armchair philosophy of John Kelly, the quartering of Bill Orchard, the central-timing of Bill Schworm, the pianoing of Mrs. Sam Baxter, the . . . ah well—in fact, just as well! At any rate, weather schmeather, this was the first meeting with 100 per cent attendance in many, many years.

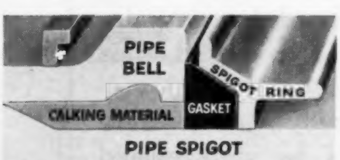
In the rocks, rather than on them, is apparently the way drinks are to be found on the moon. And as the drinks are strictly zero proof and as the rocks must be heated to temperatures of 2,700° to extract the 5 per cent drinkable, we're not about to blast off quite yet. Somehow, we prefer to remain earthbound and get blasted in our own way, using rocks that contain twenty times as much water and our practiced speed to see that no more than 5 per cent of it is extracted from them.

The waterman's ball has just been kicked out of bounds by Commissioner Armand D'Angelo of the New York Department of Water Supply, Gas, and Electricity. Having noted with understandable envy the burgeoning of the welfare funds of the fire department and the police department as a result of the purchase of ball tickets by private businessmen, employees of the water department decided that their fund could stand outside augmentation, too. They had actually obtained over 100 contributions from businessmen who dealt with the department when the commissioner learned of the kick-in plan and blew the whistle. All contributions have now been returned, department policy has been underlined, no one has been disciplined, and private citizens have been hoping that the fire and police commissioners take note.

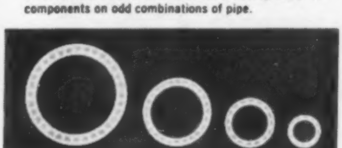
(*Continued on page 40 P&R*)



The real secret to stopping leaks with CIP Bell-Joint Clamps



Style 60's complete adjustability fits both standard and pre-standard pipe perfectly. Your Dresser Distributor can also recommend methods of using Style 60 components on odd combinations of pipe.



In all sizes, from 3" to 60", gasket sealing surfaces are at least twice the caulking space to allow for deflected and off-center joints.

Uniform gasket pressure, all around the bell face, is the key to successfully clamping bell joints. The rough face of the caulking is impossible to pack properly with a hard gasket. Yet, a soft gasket tends to flow and lose bolt torque in a matter of days. Only Dresser® Style 60 Bell Joint Clamps have specially compounded gaskets to give "just right" hardness...low permanent set...and aging resistance. ■ Your Dresser Distributor is anxious to give you the full story on the Style 60 as well as Dresser's complete line of pipe coupling and repair products. Call him today. Or write Dresser Manufacturing Division, 65 Fisher Avenue, Bradford, Pennsylvania.

dmd
DRESSER
MANUFACTURING DIVISION
BRADFORD, PENNSYLVANIA

DRESSER INDUSTRIES, INC.
OIL ■ GAS
CHEMICAL
ELECTRONIC
INDUSTRIAL

(*Continued from page 38 P&R*)

This Month Years Ago

March 1861—At Augusta, Ga., two settling basins and a clear-water basin were placed in service to remove some of the clay from the water in the local power canal leading from the Savannah River several miles above the city. After settling, the water passed to the clear-water basin through ¼-in. joints in brick paving. The second settling basin was meant to include a filter, but its completion was prevented by the war which began the following month.

March 1886—James H. Blessing obtained his first filter patent, which involved a "sand screen" of gravel in a chamber below the bottom of a filter and a revolving agitator to clean the gravel.

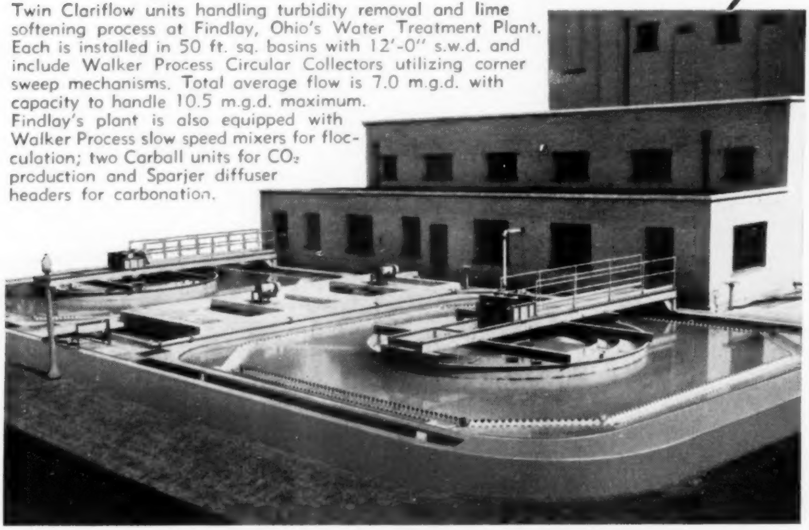
March 1911—Citizens of Springfield, Ill., were amazed at the disclosure that 6,000 of 9,000 homes in the city did not use city water and sewers, that 5,000 homes directly on sewers and water mains did not utilize them, and that there were more than 6,000 privy vaults and more wells in the city. In searching for a cause for the unusually heavy typhoid mortality experienced in the city, the public supply was found safe for drinking, but an analysis of water from 150 private wells showed all but three to be unsafe.

(*Continued on page 44 P&R*)

WALKER PROCESS

Clariflow

Twin Clariflow units handling turbidity removal and lime softening process at Findlay, Ohio's Water Treatment Plant. Each is installed in 50 ft. sq. basins with 12'-0" s.w.d. and include Walker Process Circular Collectors utilizing corner sweep mechanisms. Total average flow is 7.0 m.g.d. with capacity to handle 10.5 m.g.d. maximum.
Findlay's plant is also equipped with Walker Process slow speed mixers for flocculation; two Carball units for CO_2 production and Sparjer diffuser headers for carbonation.



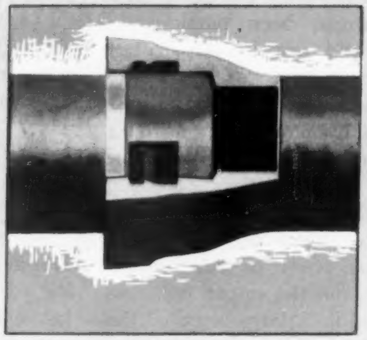
The Clariflow combines flocculation, good fluid mechanics and clarification in a relatively small tank. Mixing, flocculation, stilling and sedimentation are independently operated and controlled. The positive control of flocculation and clarification enables the operator to readily select the most economical method of operation when handling changeable water conditions.

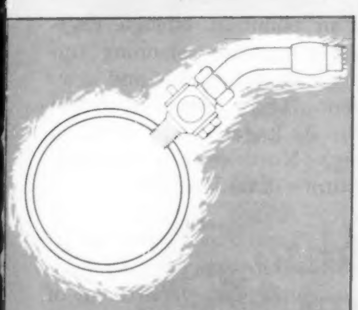
Short circuiting tendencies are eliminated by means of exclusive multiple, tangential diffusers which simultaneously and equally distribute the flow. Balanced multiple surface weir troughs make efficient use of short detention periods and insure clarified overflows.

The Clariflow is applicable wherever there is a municipal or industrial need for water or waste treatment. It can be used in all operations including combined intimate chemical homogenizing, flocculation and clarification in rectangular, square or circular basins. The Clariflow gives excellent results in the treatment of municipal and industrial water for—softening—turbidity removal—color removal—algae removal. Industrially it is universally used in—oil separation and emulsion breaking plants—blast furnace flue dust thickening—paper stock reclamation.

Write for bulletin 6W46.

WALKER PROCESS EQUIPMENT INC.
FACTORY—ENGINEERING OFFICES—LABORATORY
AURORA, ILLINOIS





(Continued from page 40 P&R)

Winter complaint, exhibiting some of the same symptoms of pressure as summer complaint, seems to be hitting water utilities especially hard this year:

At New York, where winter has, as members of AWWA's Board of Directors will attest, been particularly rugged, more and worse main breaks than usual have been plaguing the water department. Perhaps the worst of them was a break in a 48-in. main on the morning of Jan. 24, the day of the New York Section luncheon meeting. With repairs complicated by power and other lines, pressures were reduced to the point of cutting out service entirely on the upper floors of office buildings in a large area of the city. And Chief Engineer Ed Clark had something to talk about in introducing the luncheon speaker.

At Detroit, too, particularly in the suburbs, mains were popping even more frequently than their usual winter way.

At Stamford, Conn., pressurelessness came from another source, as ice clogged the screens of one of the reservoir intakes.

And at Baltimore, Md., firemen were reported to be starting fires to fight fires in their effort to coax water out of frozen hydrants.

But nowhere was the trouble as bad as at Escalante, Utah, where 12 miles of the city's 4-in. supply line completely froze when a pressure valve failed to function and let the below-zero temperatures go to work. Just about everything shut down in Escalante and every able-bodied man and boy turned out with shovel and axe to excavate the line and thaw it out with bonfires. When breaks caused by the freezeup and the length involved proved that impossible, plans were changed to break the line near the Escalante River, a mile away from town, and to pump an emergency river supply into the city reservoir with the idea of using a portable steam generator to heat water before it was pumped into the city mains. Meanwhile, trucks hauled 30,000–35,000 gpd into the community of 800 citizens, and housewives took on the new job of boiling water until the community's spring supply could be restored—in the spring.

With winter here, ...

Nuts to the San Francisco Water Department are a profitable commodity. In 1960, the 103 tons of walnuts harvested on watershed lands in Alameda County netted the department $30,000. If they did as well on a weight basis with water, they would be earning $1.21 per gallon. That *would* be the nuts!

Northwestern University has announced a number of research traineeships and fellowships in the field of sanitary engineering and environmental health. These are available for M.S. and Ph.D. candidates with research interest in air pollution, biologic engineering, water resources planning, operations research, and water and sewage treatment. Those interested should write: John A. Logan, Dept. of Civil Engineering, Northwestern Technological Institute, Evanston, Ill.

Warren J. Scott has retired as director of the sanitary engineering division of the Connecticut Department of Health. A member of AWWA since 1922, he is a Life Member and a recipient of the Fuller Award (1953). He served as director from the New England Section in 1941–44.

(Continued on page 88 P&R)

Detroit Technical Program

MONDAY MORNING, June 5

General Session

AWWA Progress .... C. F. Wertz
Financing Water Utilities .... Milton J. Redlich
Water Resources in the US .... *Senator* Robert S. Kerr

MONDAY AFTERNOON, June 5

Distribution-Management Divisions—Operations

What Is Adequacy in Water Utility Operations?—*Symposium* .... *Led by* Gerald E. Arnold
- Managerial Qualifications .... Jack McCullough
- Consumer Service .... M. D. Lubratovich
- Rates .... Henry J. Graeser
- Plant Facilities .... William R. Seeger
- Accounting Practices .... Ralph L. Swingley
- Engineering and Engineering Records .... E. Jerry Allen
- Planning .... James W. MacLaren
- Public Relations .... Johnie E. Williams

Purification Division—Processes

Experiences With Anthracite Sand Filters .... Walter R. Conley Jr.
- Discussion .... Thomas R. Camp

The Nature of Organic Color in Water .... A. P. Black & Joseph Shapiro
Instrumentation and Automation .... Ellwood H. Aldrich

TUESDAY MORNING, June 6

Open Session—Committee on Professional and Administrative Practice

Purification Division—Quality

Mineral Salt Tolerances in Irrigation Water .... L. V. Wilcox
Removal of Algae by Microfilters .... A. E. Berry
Physiological and Health Aspects of Water Quality—*Committee Report* Herbert O. Hartung
Water Quality Standard .... Elwood L. Bean

TUESDAY AFTERNOON, June 6

Open Session—Committee on Standardization

Water Resources Division—Quality

Water Resources and Problems of Michigan .... Norman Billings
Water Quality—*Joint Discussion*
- Pathogens .... Beverly W. Miller
- Detergents .... S. Kenneth Love
- Preventing Contamination of Our Water Resources .... Paul Bolton
- Food and Paper Processing Waste Disposal Practices .... Richard L. Woodward

(*Continued on page 48 P&R*)


MUELLER
for fast,
easy
service
connections!

(*Continued from page 46 P&R*)

WEDNESDAY MORNING, June 7

General Session

What AWWA Does for You....John W. Cramer
Report of Committee on Aims and Objectives....Fred A. Eidsness
Hydrologic Processes of Water, Snow, and Ice at High Altitude....Fred A. Camp

WEDNESDAY AFTERNOON, June 7

Management Division—Quality

Water Quality As It Affects Management—*Joint Discussion*
Relationships With US Public Health Service....Omar C. Hopkins
Technical Surface Water Aspects in the Great Lakes Area....Arthur Rynders
Technical Ground Water Aspects in the Great Lakes Area....Lynn M. Miller
A Case History of Public Relations....Leo Louis

Water Resources Division—Supply

Colorado River Study....Floyd E. Dominy
Duplicate Water Storage....J. Ray Heath
Water Supply on the Moon....Harry N. Lowe Jr.

THURSDAY MORNING, June 8

Water Utility Advancement Session

AWWA Advancement Program....Eric F. Johnson
Guided Discussion of the Program....*Led by* Robert F. Orth, John H. Murdoch, Samuel S. Baxter & Lewis S. Finch

Purification Division—Treatment

Progress in Saline Water Conversion—*Task Group Report*....Rolf Eliassen
Operating Results in Four Filtration Plants in Detroit....Albert M. Shannon
Committee Reports

Distribution Division—Quality

Maintaining Quality in Distribution Systems—*Joint Discussion*..*Led by* Frank E. Dolson, Oscar Gullans, H. C. Medbery, Benjamin C. Nesin & H. J. Ongerth
Pressure Zoning and Maintenance of Distribution Systems....E. S. Mamrelli
Right-of-Way Acquisition....Henry J. Graeser

THURSDAY AFTERNOON, June 8

Water Resources Division—Quality

Diffusion of Radioactive Materials in Surface Streams....R. C. Godfrey
Controlled Induced Recharge....Morris Deutsch
Water Use in the US....Kenneth A. MacKichan
Operating Experiences Under New Water Laws....George E. Ferguson

(*Continued on page 50 P&R*)

(*Continued from page 48 P&R*)

Distribution Division—Design and Operation

Peak Demands in Residential Areas....................................Jerome B. Wolff
Putting Peak-Demand Data to Work in Operation and Design..........Holly A. Cornell
Demand Rates for Water Service..W. L. Patterson

Social Program

DAY	TIME	EVENT	PLACE
Sun.	1:00 PM	Exhibit Open House	Cobo Hall Exhibit Area
Sun.	8:00 PM	Meet & Greet Night	Cobo Hall Ballroom
Mon.	11:30 AM	Fashion Show & Luncheon	Rooster Tail Restaurant
Mon.	8:30 PM	Awards & Reception	Cobo Hall Ballroom
Tues.	8:00 AM	Golf Tournament	Hillcrest C.C., Mt. Clemens
Tues.	——	Sugar & Spice Breakfast & Tour	——
Tues.	7:30 PM	Carnival Night	Cobo Hall Convention Arena
Wed.	7:30 AM	Fuller Award Breakfast	——
Wed.	10:30 AM	Outdoor Barbecue & Tour	Greenfield Village
Wed.	12 Noon	Manufacturers Luncheon	——
Thurs.	2:00 PM	Ladies Boat Trip	Leave foot of Woodward Ave.
Thurs.	6:30 PM	Annual Banquet & Ball	Cobo Hall Ballroom

Professional Services

Professional Services

Professional Services

Professional Services

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); NSA—Nuclear Science Abstracts; PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

FOREIGN WATER SUPPLIES—GENERAL

The Chemical Properties of the Waters of the El-Omoum Drain and the Local Wells in the Mariut Region. M. A. Abdel Salam; A. G. I. Mitkees; & S. A. Sabet. *Agr. Research Rev.* (Cairo), 37:158 ('59). The waters were examd. with respect to the total concn. of sol. salts, the Na adsorption ratio $[Na/(\sqrt{Ca + Mg}/2)]$, and the residual carbonate. The well waters vary in quality, and the salt content ranges from 2,000 to 9,000 ppm. Na adsorption ratio values are within a dangerous range that might produce harmful levels of exchangeable Na, although some are extensively utilized at the present time. Waters of the El-Omoum drain also vary, with an av. salt concn. below 2,000 ppm, which is within the dangerous range according to the system of classification adopted.—*CA*

An Annual Study of the Nile Water From Seven Different Localities. A. H. I. Moustafa et al. *Agr. Research Rev.* (Cairo), 37:231 ('59). The org. and inorg. contents vary throughout the year, esp. during the flood period. Residual carbonate is rather low and the ratio of Ca plus Mg to Na is high. The Nile water is suitable for irrigation all year round.—*CA*

The Freezing-Point Depressions of Baltic Sea Waters. Aarno Voipio. *Suomen Kemistilehti* (Helsinki), 33B:35 ('60). The fp of several brackish sea-water samples were detd. by the Beckman method. A new empirical equation was derived for the relation between the fp and chlorinity in the range 0–10 parts per 1,000. The equation is $\vartheta = 0.002 + 0.102\ Cl - 0.000669\ Cl^2$, in which the chlorinities, Cl, are in parts per 1,000.—*CA*

Vitamin B_{12} Content in Sapropel of Several Latvian P.S.R. Lakes. E. Kaleja. *Latzijas P.S.R. Zindtnu Akad. Vestis,* No. 10, 153 ('59). Vitamin B_{12} content and microflora in the sapropel of 5 Latvian lakes were studied. *Esch. coli* was used as the test organism, and paper chromatography for the identification of vitamin B_{12}. Vitamin B_{12} content in a 10–100-cm surface layer of sapropel was (γ/kg, dry basis): Kaniera Lake, 38.4–875; Dunu Lake, 220–356; Babite Lake, 150–799.9; Limbazi Lake, 56; and Engure Lake, 1,500. Vitamin B_{12} content varied according to season: highest in fall and lowest in winter (correlation with microflora of sapropel). Of 266 strains of aerobic bacteria isolated from sapropel, 13.8% synthesized vitamin B_{12}. These vitamin B_{12}-synthesizing bacteria were gram-pos. strains (rodlike) of sulfate-reducing (H_2S-producing) bacteria (**I**). Paper chromatography disclosed that the vitamin B_{12} active principle consisted of vitamin B_{12} and its pseudovitamins.—*CA*

Ground Water Recharge From Precipitation at Ujkigyos. L. Lovas & L. Szabo. *Hidrol. Kozlony* (Budapest), 38:313 ('58). It was planned to provide a water works supplying 6,000 cu m/day of ground water at Ujkigyos, Hungary. As there are no natural watercourses in the area, it was necessary to det. the amt. of recharge of ground water that would occur as a result of local pptn. The methods used for this purpose are described. It was possible to establish the amt. of pptn. which could be safely taken into account for recharging the ground water, and it was therefore possible to det. the extent of the catchment area necessary to insure the volume of water required, if the water works were supplied by infiltrating pptn. only.—*WPA*

Belgium, the Netherlands, and Luxembourg—A Geographical Study of Public Water Supply. S. Gregory. *J. Brit. Waterworks Assn.,* 42:73 ('60). The present

(*Continued on page 62 P&R*)

(*Continued from page 60 P&R*)

and future water demand and water supplies of Belgium, the Netherlands, and Luxembourg are considered from the geographic point of view, and the geology of the various regions, the pop. distribution, the distribution of surface and ground water supplies, and the water undertakings providing potable water in the Benelux countries, are discussed in detail.—*WPA*

Water Resources of Transvaal, South Africa. *Water and Water Eng.*, 63:519 ('59). A brief description is given of the water resources of Transvaal, South Africa. The Vaaldam impounds 521,000 mil gal, but during drought periods this may be much reduced. Measures which could be taken to provide the estd. domestic and industrial water requirements for Transvaal in the year 2000 are outlined briefly, and consist mainly of obtaining further supplies from the Vaal river, by dams, and from the Caledon river, and re-use of effluents.—WPA

How Cruz del Eje Obtains Its Water. E. J. Rodriguez. *Rev. Obr. sanit. Nac.* (Buenos Aires), 41:197 ('59). The development of water supplies at Cruz del Eje, Argentina, is reviewed historically, with particular reference to the dam on the River Cruz del Eje, which was completed in 1943, and to the pumping and distribution systems. Supplies, for a pop. of 22,500, are now obtained both from the impoundment (the river water being treated by sedimentation and slow sand filtration) and from wells. The well water is of inferior chem. quality, but after mixing with that from the treatment plant, the water obtained is suitable for drinking purposes. The river water is treated with liquid chlorine both before sedimentation and after filtration, in doses sufficient to give a residual content of 0.05–0.15 mg/l; and the well water is chlorinated at the wells with doses of 0.10 mg/l. Tabulated data are included on the chem. anal. of the water at various stages of treatment. A total quantity of 540 cu m/hr is available, of which 110 cu m is drawn from the wells.—*WPA*

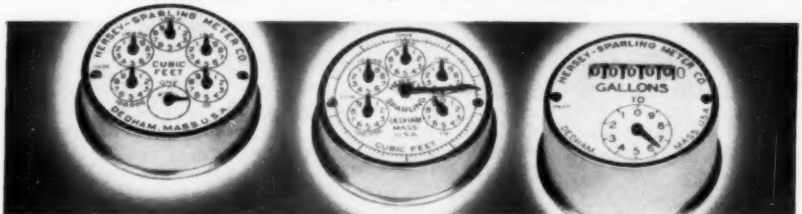
Water Supply at Jachal. J. E. Stefano. *Rev. Obr. sanit. Nac.* (Buenos Aires), 41:210 ('59). Jachal, in the province of San Juan, Argentina, obtains its water supplies from an impoundment on the River Jachal. The river water is very hard and contains high concn. of chloride and sulfate. Treatment consists of grit removal, coagulation with aluminium sulfate, adjustment of pH value with calcium hydroxide, sedimentation, slow sand filtration, and disinfection with hypochlorite. The distribution system, serving a pop. of 7,600, is described, and data are tabulated on the water consumption in each month of 1958 and on the physicochemical characteristics of the raw and treated water, both in May and November.—*WPA*

Measuring Plants of the Trier Water Supply, Especially of the Riveris Impounding Reservoir. K. Beck. *Gas- u. Wasserfach.* (Ger.), 100:136 ('59). The water supply of Trier is drawn from the Riveris impounding reservoir, small works at Kenn and Euren, and the Herrenbrünnchen and Olewig works from which separate, for example industrial, supplies are drawn. Water from the impounding reservoir, after the head is utilized by passing through a small power works, is treated at the Irsch filtration plant. A detailed illustrated description is given of the central recording and control building from which the treatment and distribution of the supply and the operation of the power works are controlled by 1 man. Specially designed measuring and controlling instruments are described.—*WPA*

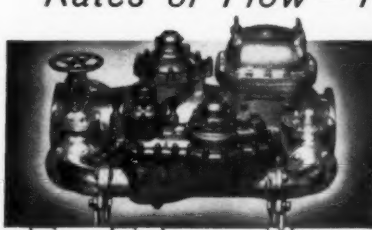
Condition and Development of Water Supply in Hungary. W. Sperling. *Gas- u. Wasserfach.* (Ger.), 99:1225 ('58). Uncertainty as to the extent and type of the developing Hungarian industries makes it impossible to est. water demand even for the near future. The sources of supply for the four large industrial areas are described. As resources of ground water suitable for domestic supply are limited, it is recommended that surface water should be used for industrial supply. In Budapest, it will be necessary either to have a separate industrial water supply or to remove factories to the city borders near the Danube. Only 29% of the pop. are served by public water supplies. The requirements for new supplies are discussed, and the progress made in repairing war damage and developing water supplies, and the types of water sup-

(*Continued on page 64 P&R*)

For Instant Unimpeded Water Flow



For Accurate Measurements of <u>ALL</u> Rates of Flow—You Can Depend on a



UL — Listed under Reexamination Service, Underwriters' Laboratories, Inc.

FM

ULC

Sizes 6", 8" and 10" of Model FM-CT are listed as standard under the reexamination service of Underwriter's Laboratories, Inc. and approved by Factory Mutual Laboratories for use in Factory Mutual insured properties, also listed by Underwriter's Laboratories of Canada.

HERSEY

Detector (FIRE SERVICE) Meter—Model FM-CT

This compound type meter combines a Proportional Meter and an Automatic Valve on the main line with an all bronze Compound Meter on the by-pass. Result: all rates of flow are measured with minimum loss of head and with minimum obstruction when full pipe capacity flow is demanded for an emergency, such as extinguishing fires.

Hersey-Sparling
Meter Company
HERSEY PRODUCTS
DEDHAM, MASSACHUSETTS

Branches: Atlanta, Boston, Chicago, Cleveland, Dallas, Denver, Kansas City, Mo., Los Angeles, New York, Philadelphia, Portland, Ore., San Francisco, Seattle

(*Continued from page 62 P&R*)

ply used in towns and rural communities, are described. The author deals with various methods of economizing on water within factories by alterations of processes and by reuse. Problems of reuse, especially those of quality, temperature, pressure, and pollution, are discussed, and diagrams are given showing possible methods of economizing by use of closed circuits.—*WPA*

Reconstruction and Enlargement of the Santo Amaro Water Treatment Plant, Sao Paulo. A. CUNHA. *Rev. Dep. Aguas Esgotos Sao Paulo,* No. 26, 15 ('55). Water for the city of Sao Paulo is obtained from the River Guarapiranga and treated at the Santo Amaro works by addition of aluminium sulfate and lime, mixing, sedimentation, rapid sand filtration, and chlorination. The reconstructions carried out up to the end of 1953 gave a supply of 86,400 cu m/day, and improved the quality of the treated water, which has a turbidity of 1–2 ppm, compared with 28 ppm in the raw water, and contains no coliform organisms in 100 ml. Further modifications which have been planned to double the capacity to 172,800 cu m/day are listed. Cross-sectional diagrams of the old Reisert filters and the modifications are included. Numerical data on the size and performance of the various sections of the plant are appended, including the physical, chemical, and bacteriologic characteristics of the raw and treated waters.—*WPA*

The Marquesado Water Treatment Plant. *Rev. Obr. sanit. Nac.* (Buenos Aires), 41: 172 ('59). An illustrated description is given of the new Marquesado water treatment plant and associated pipelines and storage facilities, designed to supply an additional 60,000 cu m/day to San Juan, Argentina. Water obtained from the San Juan River is treated by grit removal, coagulation with aluminium sulfate, and adjustment of pH with $Ca(OH)_2$, sedimentation, and rapid sand filtration, followed by adjustment of pH and disinfection with chlorine.—*WPA*

(*Continued on page 66 P&R*)


7575

(*Continued from page 64 P&R*)

Limnological Study of the Reservoir Sedlice Near Zeliv. I. Physical-Chemical and Chemical Part. J. Chalupa & R. Cervenka. *Sci. Papers Inst. Chem. Technol., Prague, Fac. Technol. Fuel Wat.,* 2:151 ('58). Studies are being carried out at the Sedlice Reservoir in south-east Bohemia to obtain information on the changes in quality of the water during storage. Results are being published in a series of papers. In this paper, the reservoir is described and data obtained in 1955–56 are reported, for the reservoir water and the inflow and outflow water, on temp., DO, and chemical characteristics, particularly the contents of potassium, sodium, and electrolytes. The reservoir receives water from the rivers Kletecna and Hejlovka, and the latter is polluted during the starch-processing season in autumn. The dissolved solids carried into the reservoir at this time are not eliminated by the slow processes of self-purification in the winter, but are only removed when the water is replaced by inflows of unpolluted water after the end of the starch-processing season. **II. Biological Part.** M. Stepanek & J. Chalupa. *Sci. Papers Inst. Chem. Technol., Prague, Fac. Technol. Fuel Wat.,* 2:313 ('58). Observations in 1955–56 on the plant and animal communities in part of the Sedlice Reservoir, Czechoslovakia, are reported and discussed in relation to the troubles caused by mass development of plankton organisms. The distribution of plankton is considered in relation to pptn. and wind direction in the area, transparency of the water, temp., and DO; and seasonal variations in the cont. of individual plankton groups are summarized. The benthic fauna were also examined, using a trap of modified design. On the basis of the results, a scheme is proposed to explain the seasonal changes in the counts of organisms.—*WPA*

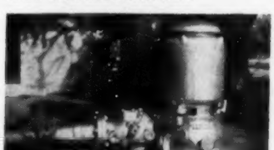
Softening of Water Supplies in Foreign Water Works. W. Gandenberger. *Gas- u. Wasserfach.* (Ger.), 100:84 ('59). Central softening of water supplies has not been adopted in Germany, though 40% of the supplies have a hardness of 10°–20° (German)

(*Continued on page 68 P&R*)

"The service is rough, but we've never experienced a pump failure since the first Peerless pump was installed in 1932."

Says Farrell McLean, Water Superintendent Carlsbad, New Mexico

This is one of the ten Peerless Deepwell Turbine Pumps used to supply the entire city water supply. Pump setting is 80' with 1800 GPM flow.



First installed in 1932, this Peerless pump is still on the job. Like the other nine pumps, this unit is handling water with 50 grains total hardness per gal.

Pumping water with 50 grains of Total Hardness per gallon is rough service in anybody's language. Yet that is exactly what Peerless Deepwell Turbines have been doing, better than 28 years for the city of Carlsbad, New Mexico. The first installation was made in 1932. And, through the years, nine more units have been added to the field to meet the city's increasing water needs. The pumps are operated on continuous duty for periods ranging from four to six months and semi-continuous duty the balance of the year. To date they have never had a pump failure and even the regular maintenance programs call for pulling pumps only every six to seven years for inspection. For the complete story on Peerless Deepwell Pumps, write us.

PEERLESS PUMPS fmc

PEERLESS PUMP

HYDRODYNAMICS DIVISION

FOOD MACHINERY AND CHEMICAL CORPORATION

301 WEST AVENUE 26, LOS ANGELES 31, CALIFORNIA

(*Continued from page 66 P&R*)

and about 20% have hardness of over 20°. In America, 5°–6° is regarded as the desirable hardness, and supplies with more than 10°–12° are softened. The domestic and industrial advantages of soft water and the costs of softening are discussed and brief accts. are given of the various processes of softening by lime and by ion exchange. The author then discusses, with descriptions of American methods and plants, the disposal of sludge from softening plants.—*WPA*

Investigations Into Horizontal Filter Wells in the Berlin District. K. HUNERBERG. *Gas- u. Wasserfach.* (Ger.), 100:862 ('59). An acct. is given of the results of investigations in 3 horizontal filter wells in the Berlin district. The geology and the arrangements by which samples can be drawn from and flow measured in each horizontal shaft are described. Details are given of the water intake of different shafts, the amt. of sand introduced, the alterations taking place in the course of use, and the effects of variations in the number of shafts. —*WPA*

The Content of Selenium in Saale Water. F. HEIDE & P. SCHUBERT. *Naturwissenschaften* (Ger.), 47:176 ('60). Results are given of investigations into the content of selenium in the water of the River Saale. Monthly samples were taken at Goschwitz during 1954, and samples were taken at various places along the river on July 6 and 7 of that year. The yearly average for dissolved selenium was 3.9 μg/l; and for selenium in suspended matter, 1.2 μg/l. Selenium values were high at times of high flow and after rain. Increases were observed below a cellulose wool factory and below the town of Jena. High values for selenium corresponded with low values for sulfur. Selenium is generally present as selenide or in elementary form in hydrolysate, whereas sulfur is generally oxidized to sulfate.—*WPA*

Post-War Development of the Water Company Serving the Northern Part of the German Coal Mining Area. V. SCHWING. *Das Gas- und Wasserfach.* (Ger.), 100:934 ('59). The development of large water works in West Germany in the last 100 years is described, with emphasis on the plants built or rebuilt since World War II

(*Continued on page 72 P&R*)

(*Continued from page 68 P&R*)

in coal mine areas. New plants serving communities and industries are illustrated and described briefly. These developments represent sizeable financial investments.—*PHEA*

Modifications at the Weiler Water Works at Cologne. E. HOLLER. *Das Gas- und Wasserfach.* (Ger.), 101:227 ('60). Water for the Cologne area left of the Rhine River is drawn from 2 ground water strata. In the north of the city, the Weiler Water Works has been boosted to yield 68,000 mil gal annually. The existing syphon system was abandoned because of expected drawdown. As a result of tests carried out in 2 test holes, the existing gallery was substituted by 23 new wells equipped with pumps. A chart explains the performance of the new wells. A yield of 23 mgd for 3.3-ft drawdown and the automatic operation are significant features of the new installation. The power supply is reliable and includes automatic control. Each pump may be operated with push buttons, or automatic special operation equipment adapts the low-pressure pumps to the high-pressure pumps. This setting is demonstrated in graphs.—*PHEA*

The New Osnabruck Water Works. G. ULSMANN. *Das Gas- und Wasserfach.* (Ger.), 101:380 ('60). A new ground water works shall boost the capacity of 3 existing works. After geophysical and hydrologic investigations and after 1 year of test well operation annually, 5,000,000 cu m of ground water are collected by 16 gravel wells. The water is treated by spray aeration, neutralization, manganese removal (coagulation), and rapid sand filtration. Experience leads to most economical operation producing iron- and manganese-free water. The treatment plant consists of a pumping station, chemical plant, and filters. An 18-km cast-iron main line (600-mm diameter) was laid under difficult circumstances in ground water, crossing one main railway track and one inland waterway. A new hydraulic method was applied to cross the waterway. A cast-iron line connects the prestressed-concrete reservoir with a delivery station at the city line. Total costs: 16.5 mio marks.—*PHEA*

A Modernized Water Supply for the Royal Borough of New Windsor. P. R. JEFFCOATE. *Water and Water Eng.*, 64:97 ('60). Water for the Royal Borough of New Windsor and the Eton Urban District is supplied by reciprocating pumps delivering directly to the distr. mains. There is no service reservoir and no pressure relief or safety valve on the main system which serves a pop. of 32,000. Difficulties due to excessive drawdown during the periods of high extraction a few hours each day, increased difficulty in maintaining adequate but not excessive pressures, and problems associated with continuous plant operation required that a reservoir be incorporated into the existing system. A 3-mil gal reservoir and booster station are now being constructed in such a way that service is not being interrupted during installation.—*PHEA*

Rural Water Supplies: New Developments in North Devon. K. J. YOUNG. *Roy. Soc. Promotion Health J.*, 78:772 ('58). The North Devon Water Board, created in 1945, serves 1,000,000 acres, the largest area of supply covered by any water authority in the British Isles. Owing to rapid progress in supplying villages and farms in the area, there is need to develop further water sources. Originally, it was proposed to dam the Taw River, at a cost of £1,000,000. Deep wells are not feasible due to dense underlying shale and sandstone. The article outlines the author's alternative plan for tapping the river marsh with a series of 72-in. wells, to a depth of 50 ft. This plan was initiated in the summer of 1959.—*PHEA*

The Mineral Waters of Baikal Region. V. G. TKACHUK & G. A. ANKUDINOVA. *Trudy Vostochno-Sibir. Filiala, Akad. Nauk S.S.S.R.*, No. 10, 97 ('59). There are close to 400 mineral springs on the territory of Eastern Siberia, Baikal Lake region included. The main geol. features of the Baikal region are discussed. Twenty-five sources of mineral waters are described; the location and chem. analyses are given. The mineral waters of the region are divided into 2 groups: cold and hot. The cold-water springs are bicarbonates; the water of the Zhemchug Iron Springs is of a sulfate-bicarbonate type. The waters of hot springs form the group of water with sulfates prevailing (sulfate, chloride-sulfates, bicarbonate-sulfate, and mixed bicarbonate-chloride-sulfate). Only in a few cases do bicarbonates

(*Continued on page 74 P&R*)

(Continued from page 72 P&R)

prevail in anions of thermal springs, as in the wells of Sukhaya Zagza and Tunkinsk (bicarbonates), in the springs of Kulinnye Marshes (chloride-bicarbonate) and Seyuiskii (mixed bicarbonate-chloride-sulfates). There is a certain relation between the water compn. and the temp. The waters of 20–40°C are purely bicarbonate or chloride-bicarbonate. The largest group of springs has a temp. of 40–60°C, and is mostly sulfate or bicarbonate-sulfate. Garginskii Spring (75°C) is purely sulfate, Allinskii (72°C) and Urinskii (66°C) are bicarbonate-sulfate springs. Bol'sherechenskii and Kotel'nikovskii springs are of a mixed type, with high and almost equal content of chlorides (40.7 equiv. %) and sulfates (41.7 equiv. %). The cation content of water of all hot springs is typical for alk. waters; complete absence or low Mg content is characteristic. The waters of cold springs are more diverse; among them are Ca, alkali-Ca, and Ca alk. The low mineralization of water is characteristic for all the springs: hot springs have a higher mineralization, 300–1,000 mg/l; the mineralization of cold springs is 100–200 mg/l. Water of Kolmar springs contains 7 mg/l of H_2S. Zhemchug spring has a high Fe content and known therapeutic properties. The medical qualities of Baikal springs are not yet well studied.—*CA*

Waters of the Metohija Region Used in Irrigation. D. Babovic. *Zemljiste i biljka* (Belgrade), 7:439 ('58). The waters under discussion are rather peculiar, as none of them is high in salt, but they are relatively high in $CaCO_3$ (about 85% of the dried residue). After heavy rains, the waters contain large amts. of silt. They readily bind P_2O_5; their greatest disadvantage is the low temp. (avg. of 16°C), as they are used for the irrigation of rice fields; furthermore they increase the podzolization of the soil.—*CA*

Hydrochemistry of the Selenga River. P. F. Bochkarev. *Trudy Irkutsk. Univ.* (USSR), 24:143 ('58). Hydrochem. characteristics of the Selenga River, the main tributary of the Baikal Lake, are given. The water is little mineralized. The principal ions vary from 92 to 225 mg/l during the year; the mean annual total of ions is 129.3 mg/l, with variations during the year from 96.5 to 212 mg/l. Max. mineralization is observed when the river is covered with ice (January–February), and the min. in May. The water is characterized by the predominance of HCO_3^- and of Ca^{++} ions over other ions. The HCO_3^- content changes from 60 to 70 mg/l in summer flooded state to 140–150 during the time under ice. The Ca^{++} content varies during the year from 15 to 35 mg/l. The content of other ions is as follows: SO_4^{--}, 6–15; Cl^-, 1–4; NO_3^-, 0.095–0.350; Mg^{++}, 1–6; $Na + K^+$, 2–25 mg/l. The equation of carbonation is $Eu = (HCO_3^-)\ 1.35 + 8$, but the mean ion compn. is $Eu = (HCO_3^-)\ 1.36 + 10.4$. The hardness varies from 0.89 to 2.44 mg/equiv. The P in inorg. compds. varies from 0.02 to 0.65; Fe, 0.04–0.60; Mn, 0.0005–0.0006, sometimes to 0.002; and Si, 2.1–5.7 mg/l. The waters of the Selenga River and of other tributaries of the Baikal Lake are 2–7 times richer in Si than is the water of the Baikal itself; this indicates the intensity of the assimilation process of Si in the Baikal. The oxidizability of the water of the Selenga River varies from 1 to 2 mg of O per liter in the period of ice cover, to 12–16 mg of O per liter in the period of flood stage. The content of O varies from 13 to 16 mg/l, that means 110–43% of satn., whereby more than a half of the year the water remains unsatd. with O. The CO_2 content varies from 1–3 mg/l in summer to 22 mg/l in winter under ice. The pH varies from 8 to 6.8. The content of corrosive CO_2 is 0.52–16.01 mg/l. According to the data of the Mostovoi siding, the ion runoff of the Selenga River was calcd. in thousands of tons, and is as follows: Ca^{++}, 681.26; Mg^{++}, 148.24; $Na + K^+$, 154.55; HCO_3^- in conversion to CO_3^{--}, 1390.91; SO_4^{--}, 220.78; and Cl^-, 41.00. The total of the ion runoff is 2639.74. The index of ion runoff of the Selenga River is 5,800 tons/year and /sq km of the surface of the river. It is the least for the rivers of Eastern Siberia. This indicates the sluggishness of the process of chem. denudation in the basin of the Selenga River (0.002 mm/year). The total mineralization and ion compn. of the Selenga River show that the formation of the chem. compn. of the water takes place on the surface of the basin among well-washed ground soils at the expense of dissolving of erosion products of cryst. and metamorphic rocks of the Precambrian and Proterozoic eras. The comparison of hydrochem. data of the Mostovoi siding and of Novo-Selenginsk shows

(Continued on page 76 P&R)

(*Continued from page 74 P&R*)

that in spite of the considerable distance between these 2 points and the difference of space of the water catch basin, constituting 80,000 sq km, the water of the Selenga River almost does not change by its compn. and the ion runoff.—*CA*

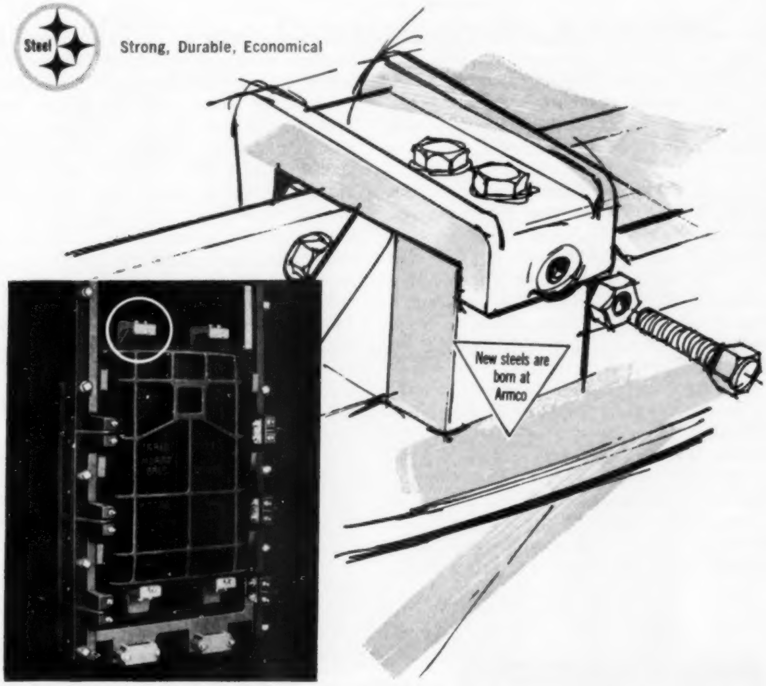
Ground Waters and Mineral Springs of Eastern Siberia. N. I. Tolstikhin. *Materialy po Podzemnym Vodam Vostochnoi Sibiri, Sbornik*, pp. 7–32 ('57). With regard to subsurface water supplies, 2 areas are distinguished in Eastern Siberia: (1) the Eastern Siberian complicated artesian basin assocd. with the Siberian platform and the adjacent marginal troughs; (2) a system of folded regions surrounding the above basin. Area 1 can also be called the group of the artesian basins of Eastern Siberia, and can be regarded as a huge reservoir of Paleozoic salt waters and brines, the latter being concd. in places. In the marginal sections, Mesozoic artesian waters are found. The presence of permafrost soils is a specific feature of the area. Within the Central Yakutian Lowland lies the world's largest basin of fresh artesian H_2O assocd. with the Jurassic and Cretaceous aquifers, underlying the zone of the permanently frozen deposits. Hydrogeol. conditions of Area 1 are described in detail. This area includes 4 artesian basins of the 1st order assocd. with depressions in the cryst. basement of the platform. The boundaries, geol. structure, and hydrogeology of each basin are outlined, including their subdivision into hydrogeol. provinces. Some of the latter present artesian basins of the 2nd order. Special emphasis is laid on the chemistry of ground waters, and numerous data on their chem. compn. are presented. In the Khatanga basin, ground H_2O contg. CH_4 indicates possibilities with regard to oil. Concd. brines contg. Br and B are common at great depths in the Yakutsk basin. Data on chem. compn. of H_2O from several borings and from mineral springs of this basin are presented. The Irkutsk artesian basin is characterized by the presence of salt waters and brines; the chem. compn. of brine from the depth 1,635–68 m is given. Of interest is the high content of K and its predominance over Na, the predominance of Ca over Mg, and the sum of K and Na, as well as an unusually high content of Br and a high content of B. This may indicate possibilities of the Irkutsk basin in regard to Br and K deposits. The higher aquifers of this basin are mineralized to a smaller degree and are known for their health-giving properties. Br-bearing springs are known within the Angara artesian basin. The folded regions (2) are listed. Rather meager data are available for most of them; only the Aldan folded massif and the East Siberian complicated folded region are investigated in some detail. The data on chem. compn. of H_2O taken at different intervals up to the depth of 673 m from a boring in the Baikal artesian basin are tabulated; the degree of mineralization here decreases with the depth. There are presented results of analyses of some of the numerous thermal springs encountered in the Baikal area, as well as data on carbonate waters of the Dauria hydromineral region (Transbaikalia). The ground waters and mineral springs of Eastern Siberia are insufficiently used for health-giving purposes and for industry.—*CA*

INDUSTRIAL WATER USE

The Sedimentation of Coal Industry Waste Waters. P. G. Meerman. *Bul. centre belge etude et document. eaux* (Liege), No. 45, 150 ('59). In a contribution to a discussion on sedimentation at a meeting in Liege, May 1959, the author considered the sedimentation of coal industry waste waters, especially the optimal conditions for operating the thickeners, including data showing that it is preferable to operate 2 thickeners in series rather than in parallel; the treatment and elimination of the sludge, with particular reference to the comparative costs of drying the sludge by filtration or centrifuging before transport and of discharging the liquid sludge to ponds or beds at a distance from the mine, including the possibility of discharging the sludge by pipeline to the sea; the utilization of the sludge for making bricks; and the mechanism of coagulation in relation to the choice of reagents. Particular consideration is given to the use of "sensitizers" in addition to the primary coagulant, and the mechanism of action of long-chain polyelectrolytes. Tabulated data are given showing the relative costs of using natural and synthetic products as sensitizers. At the Emma mine, Netherlands, where waste waters are coagulated with ferrous sulfate, the replacement of potato

(*Continued on page 78 P&R*)

Strong, Durable, Economical



Armco Gates Give You DURABLE Strength

Here's one reason why...

Detail on Armco's top wedging device for water control gates shows how Armco Gates are built for lasting strength. Note that the reinforced top wedge block is held in position by *two* cap screws for extra rigidity. Further, the adjusting screw, tapped through the back leg of the wedge block, bears against the solid cast iron boss on the casting rather than against another fastener. These three screws act independently to provide a *durable, watertight* installation.

Find out more about Armco Water Control Gates. Write to Armco Drainage & Metal Products, Inc., 4981 Curtis Street, Middletown, Ohio.

ARMCO Drainage & Metal Products

(*Continued from page 76 P&R*)

starch sensitizers by Sedipur PK3 reduced the costs by half and improved the coagulation slightly; at the Wilhelmina mine, however, when various reagents were tested, the best results were obtained by using potato starch in the form of flocgel.—*WPA*

Nature of Water of Chief Rivers in the Tohoku District From the Viewpoint of Industrial Water. T. Kato & T. Sawaya. *Technol. Repts. Tohoku Univ.,* 24:2:43 ('60). To assist in planning the location of factories, river water samples were taken and analyzed from 14 rivers, at 26 sampling locations, and over a period from autumn 1952 to the spring of 1955. Japanese standard methods for testing industrial waters were used. Results are tabulated and shown graphically. The results indicate that the condition of most of the river waters is such that some treatment is required. Varying quality with seasons is attributed largely to the amt. of rainfall. With heavy rainfall, turbidity and suspended matter increase, but dissolved solids and hardness decrease; the opposite is true in summer. Some of the smaller rivers, into which hot or mineral water is not discharged, are of good quality, but the water from the larger rivers is generally of poor quality. The poor quality is partly due to irrigation water, farming, and to wastes and sewage. Well water is apt to be harder than river water, with a higher content of dissolved matter and a higher pH. Contamination of river water with sea water near the outlet is not as great as anticipated, and the water intake can be further downstream than usual. Some of the larger rivers, esp. those that flow through farm land, become very turbid at times. A few of the rivers contain abrasive pumice in suspension. The pH varies from about 6 to 7. The content of DO averages 90 ± 5% of satn. in most cases. This is higher than observed with well water. Acidity is rarely greater than that corresponding to 5–10 mg/l CO_2, and alky. is about 20 mg/l $CaCO_3$, sometimes rising to 70 mg in a dry season. Some rivers have a high content of dissolved materials (esp.

(*Continued on page 80 P&R*)

(*Continued from page 78 P&R*)

when they pass through a mineral spring area). Changes in Cl-ion content are not large and are attributed to the population. Sulfate shows a very large change in concn. with the seasons. Chem. O demand and total N do not show a clear relation between values and the season. (High N in the summer may in some cases be due to irrigation water.)—*CA*

Investigation of Water for Ice-Manufacturing. I. Analysis of Ice-Manufacturing Water in Tokyo and Its Vicinity, and Distribution of Salts in Frozen Ice. K. Toyoda; H. Kamatsu; & E. Go. *Tokyo Toritsu Kogyo Shoreikan Hokoku,* No. 7, 123 ('58). Water used at 9 ice-mfg. plants located in Tokyo and its vicinity was examd. A marked difference was recognized between surface and subterranean water in the degrees of M-alkali (as $CaCO_3$), silica (as SiO_2), total hardness (as $CaCO_3$), carbonate hardness, and noncarbonate hardness. In the surface water, a significant difference was recognized in the amt. of silica and noncarbonate hardness with kinds of water tested. The quality of subterranean water near the sea was markedly affected by the sea water and, in general, showed higher M-alkalinity, amt. of silica, and carbonate hardness, and a lower noncarbonate hardness than surface water. Total solids in the clear part of ice block were much lower than those of the center part of ice block and unfrozen water. They increased in the order of middle, lower, and upper parts. The pH was lower in the clear part, but higher in the unfrozen part than that of original water. With regard to factors examd., such as M-alkalinity Cl^-, SO_4^{--}, SiO_2, total hardness, carbonate hardness, Mg^{++}, and Fe^{++}, the highest values were obtained in the unfrozen water which remained in the center of ice block. It seems to be important for mfg. excellent ice to solve the problem of how to conc. effectively a variety of salts in the center of ice block. —*CA*

Wastewater Transformation at Amarillo. II. Industrial Phase. D. Alexander. *Sew. & Ind. Wastes,* 31:1103 ('59). In 1954, the city of Amarillo, Tex., constructed an activated-sludge plant to treat 4.5 mgd of its 7.5-mgd sewage flow, which was to be then made available to an oil refinery for cooling and boiler makeup water, with the remaining 3 mgd to go through the existing primary plant. The contract with the refinery provided for pH between 6.8 and 9.0, limits on suspended solids of 25 mg/l, BOD of 25 mg/l, total dissolved solids of 1,000 mg/l, and a minimum chlorine residual of 0.1 mg/l. Facilities for storing 3-day effluent flow, a pump station, and 10-mi transmission line were provided by the city, with any additional conditioning to be done by the refinery. Except for a brief period when toxic industrial wastes upset plant operation, there has been little difficulty in meeting water quality specifications. Cost varies from 17 cents at low flow to 11 cents at maximum flow, compared with 18 cents per 1,000 gal for fresh water. The main advantages to the refinery are that it avoids the necessity of developing its own water supply, does not burden the city water supply, and there will be increased availability of used water as city consumption increases without adding to the scarcity of water in the area. Cooling water is treated by the cold-lime process to remove phosphate, silica, and magnesium hardness; a hot lime-zeolite process is used for boiler makeup. Continuous chlorination controls slime and algae in cooling equip.—*PHEA*

Water Problems in the Dairy Industry. *Molkereiztg, Hildesh.* (Ger.), 12:30:907 ('58). This special number contains articles on various aspects of the use of water in dairies, including removal of salts from, and sterilization of water and purification of, dairy effluent.—*PHEA*

Industries Recover Valuable Water and By-Products From Their Wastes. E. B. Besselievre. *Wastes Eng.,* 30:734, 760 ('59). Water shortages in various parts of the US both for industrial and domestic purposes show the need for greater emphasis on recovery of byproducts and treatment of wastes to permit reuse of the clarified water. Industry is developing a much more cooperative attitude, and regulatory agencies are cooperating more closely with industry in developing waste treatment requirements consistent with stream needs. Emphasis is being placed on recovery of potentially valuable waste components as a means of reducing waste treatment costs. In-plant process changes to reduce waste volumes and concns.

(*Continued on page 82 P&R*)

(Continued from page 80 P&R)

are receiving more attention. Automation in the fields of treatment operations and waste-stream monitoring greatly improves control and reduces costs. The art and technology of handling, treating, and disposal of all types of industrial wastes will see great advances in future years.—*PHEA*

Water Supplies of the Steel Industry. R. Colas. *L'Eau*, 45:259 ('58). A general description of the water supply problems of the iron and steel industry provides an introduction to a symposium on this subject. Considerable attention is given to the water pollution aspects of the problem.—*PHEA*

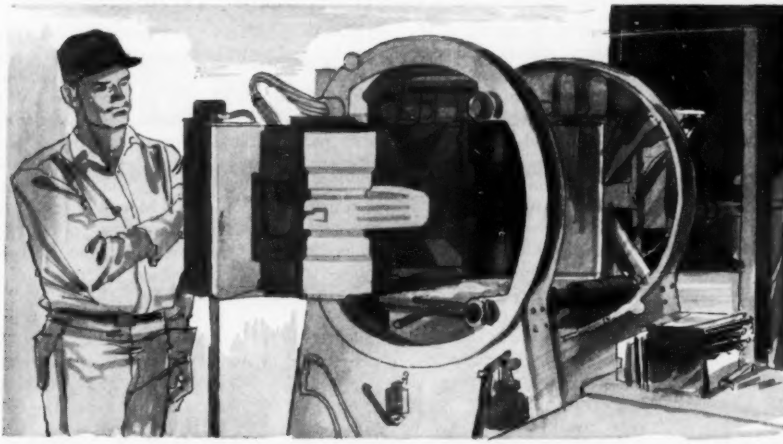
TREATMENT—GENERAL

A Particular Treatment of Domestic Waste Waters. L. Mendia & E. Buonincontro. *Acqua ind.* (Naples), 2:164 ('60). The domestic waste waters, when discharged in the sea, can be purified after grating and desanding by mixing with sea water, by electrolysis in appropriate cells, and subsequent flocculation and sedimentation of sludges. The electrolysis results in hypochlorite formation, which has a disinfecting effect. The whole purification cycle lasts 90 min. The elec. energy consumption is about 0.3 kw-hr/cu m of waste water.—*CA*

Pilot Plants for Water-Treatment Research. G. G. Robeck & R. L. Woodward. *Proc. ASCE*, 85:1 ('59). A description is given of the 3 pilot plants in use at the Robert A. Taft San. Eng. Center, Cincinnati, Ohio, for studies on various aspects of water treatment. Expts. are in progress on basic phenomena of filtration, on the operation of large coagulation and sedimentation tanks, and on the most economical method of preparing a small supply of safe water for farms. An inexpensive and safe method for treating water for farms involves filtration and disinfection by heating.—*WPA*

Highly Basic Resin for Removing Humic Acids From Water. *S. African Ind. Chemist*, 13:134 ('59). Most of the org. matter

(Continued on page 84 P&R)



(Continued from page 82 P&R)

present in water is removed by pptn. with iron chloride or aluminium sulfate, but the remainder is not completely removed by the highly basic silicic acid ion-exchange resins usually used for demineralization, and the resins become contamd. by acid absorption, which impedes regeneration. This leads to a high consumption of washing water, a long regeneration period, and loss of capacity. An ion-exchange resin has now been developed for the removal of org. matter before demineralization. The resin is highly porous and highly basic, and, when in the chloride form, absorbs the humic acid anion. Regeneration is effected by means of a 5–10% NaCl solution. Although this new process is costly, it has many advantages which offset this—namely, the constant production of high-quality water; an increase in the ion-exchange capacity of the plant; a longer life for the resins; a shorter regenerating period; and economy in the use of the regenerating agent.—*WPA*

Water Purification Plant for Charlotte, N.C. G. S. Rawlins. *Civ. Eng.*, 30:41 ('60). Hoskins water plant, completed in 1959, is located near existing raw-water earthen reservoirs supplying water by gravity to the existing Vest Station purification plant. The new raw-water pumping station contains 5 electric motor-driven low-head, propeller-type pumps—ranging in capacity from 6 to 18 mgd—and a standby diesel-engine-driven 36-mgd pump which boost water either to the new or old plant. The 12-mgd Hoskins plant includes 2 parallel flash mixing basins providing 60-sec mixing with propeller-type mixers; 2 flocculation basins providing 45-min slow mixing with variable-speed mixers transverse to direction of flow; 2 sedimentation basins providing 4-hr settling; 4 rapid sand filters employing conventional Wheeler-type filter bottoms and concrete washwater troughs; 5-mg underground clear well; and 3 vertical turbine-type pumps. Also included are 18-mgd and 12-mgd pumps driven by 500-hp and 350-hp synchronous motors, respectively, and a standby 9-mgd pump driven by a 300-hp induction motor or by a 330-hp diesel engine for high-lift pumping. There are 7 gravimetric chemical feeders and 1 carbon slurry volumetric feeder. Chlorine from ton containers feeds the 2 chlorinators. There are 2 direct-feed-type ammoniators drawing ammonia from 150-lb cylinders. Although the general control system for the plant is pneumatic, there is some transmission by electric means from remote points. Individual filters are taken off the line, washed, and put back in service by controls mounted and operated at the separate filter-operating tables. Chemical treatment controls and recorders on the main control panel consist of the chlorine rate-of-feed recorder, the multiple-sampling-point pH recorder, and a residual chlorine recorder, along with feeder-machine alarms and run indicator lights.—*PHEA*

Treatment of the Water in the Aqueducts of Lower Milan Province. G. Avogadro. *Acqua ind.* (Naples), 1:21 ('59). The section of the Province of Milano between Lido and the River Po until 1951 was practically devoid of aqueducts; since then the present 30 aqueducts have been constructed. The hydrogeol. nature of the terrain made it necessary to build H_2O treatment plants to supply the aqueducts. The treatments tried out included removal of Fe, chlorination, and deacidification, the latter by aeration to remove free CO_2 and by treatment with $CaCO_3$ or MgO suspensions. To minimize corrosion, pipes made of compn. cement, coated internally with chlorinated rubber, of poly(vinyl chloride), of polyethylene, and of steel with a bituminous coating were tried.—*CA*

Treatment of Dusseldorf Drinking Water With Active Charcoal. W. Hopf. *Gas- u. Wasserfach.* (Ger.), 101:330 ('60). The continuously deteriorating quality of the Dusseldorf potable H_2O supply led to attempts to improve the odor and taste. Active C was chosen for this purpose; after testing many samples of active C, certain lots were chosen for pilot-plant tests. Tests were made at low, medium, and high filter velocities, with and without pretreatment with Cl and O. While pretreatment with Cl increased the vol. of H_2O that could be treated by a given vol. of C, as light odor prevailed, apparently, strongly odorous substances were converted into those with less odor. Pretreatment with O had little effect. The C filter was periodically treated with Cl to prevent bacterial growth. A slight musty residual taste was always present after treatment, varying with the initial condition of the H_2O, but many times this

(Continued on page 86 P&R)

(*Continued from page 84 P&R*)

was scarcely perceptible. The quality of the H_2O was considerably improved. The C filters were washed periodically with air and H_2O to remove Fe, Mn, and other deposits. After a considerable period of use, the C-absorptive capacity was reached, and it was necessary to send the active C back to the factory for regeneration (by heating in the absence of air). After one such treatment, the C was restored to approx. its initial activity. When regeneration was repeated a 2nd time, the activity of C dropped considerably, so that much lower H_2O velocities through the filter had to be used, unless the regenerated material was used together with fresh material. Other methods of regeneration were not satisfactory.—*CA*

The Elimination of Iron From Waters With the Use of Cellulose. Y. M. Kostrikin; I. N. Gofman; & V. A. Ivanova. *Teploenergetika* (Moscow), 7:13 ('60). The practical application of the cellulose method for eliminating Fe from boiler condensates described in earlier papers is shown by the use of schematic drawings of filters and with specifications for their design and operation. Since condensates account for 50–80% of all Fe in the boiler feedwater, treatment of the flow from the return lines only is considered. From waters contg. from 0.10 mg/l of Fe up to 1.0 mg, a filtered product of 0.01 mg/l can be expected; under lab. conditions, 0.002–0.003 mg/l are not unusual. In earlier work with the use of radioactive tracer Fe, a residual content of less than 10^{-8} mg/l was observed. Pressure drops through the fresh ($t = O$) cellulose layer are correlated by means of the equation $\Delta p = 0.006\ l\ v^{1.8}$, in which Δp is in m H_2O; l, the thickness of the layer in cm; and v, the velocity of flow in m/hr. As an empirical relation, it checks closely with observed measurements. The optimum water velocity is 15–20 m/hr. Higher rates may be permissible, but they may cause shifts in the cellulose layer to disturb the flow. The optimum thickness of the layer is 5 cm, neither more nor less. Service costs are negligible since the replacement of the packing requires the labor of 2 men for 2–3 hr only 7 times a year. For filtering 100 tons/hr of water carrying 0.3 mg/l of Fe at a flow rate of 20 m/hr, 42 kg of cellulose are required at a cost of 105 rubles. Thus, the annual cost is about 800 rubles or 0.1 kopeck per ton of filtered water.—*CA*

(*Continued from page 44 P&R*)

. **No seweree, no washee** is the word in Michigan these days, not just the word either, but the law, and it is being enforced by the Michigan Water Resources Commission in respect to operators of coin-operated automatic laundries in parts of the state where no sewage facilities are available. The 1,000 to 10,000 gal of detergent-laden wastes discharged by each of 120 such laundries is causing the commission concern. As a result of the enforcement drive some of the owners have had to truck their wastes to sewers and others are looking desperately for other ways out. Thus a new diatomaceous-earth filtering system for laundry waste water, invented by one C. Gordon Rice of Florida, and distributed by a Detroit company is being looked to by the operators as the tickee to no lose shirtee.

Hawaii really joined the Union in December when Rickey Sheets, aged 10, of Kailua, put a garden hose down a gopher hole and turned on the water. You know what happened. He tried to pull it out and it wouldn't come. His mother tried and it wouldn't come. He and his mother tried and it wouldn't come. His father tried and it wouldn't come. His father tied the hose to the rear bumper of his car and, instead of coming, the hose broke. By next morning 20 ft of the hose was down the hole.

Then came physicist Iwao Miyake from the University of Hawaii and noted that the occurrence was quite common—a case of "hydraulic excavation." The water from the hose, he said, hit soft sand. When the water was turned off, sand began seeping into the hose. As the hose sought to

(*Continued on page 90 P&R*)

(*Continued from page 88 P&R*)

occupy the space formerly filled by the sand, it sank deeper and deeper.

Now the whole business is all very clear . . . to Rickey Sheets, maybe. We're just wondering when Alaska will be heard from.

Nathan S. Bubbis has been appointed director of the waste and water works division of the Metropolitan Corporation of Greater Winnipeg (Man.). Since 1949 he was general manager and chief engineer of the former Greater Winnipeg Water and Sanitary Districts.

'Careers for Engineers' is the title of a brochure published by the city of Chicago to bring employment opportunities to the attention of student engineers who will be graduating next June. Those interested in a copy of the brochure should write to Mrs. Esther Liebert, Chicago Civil Service Commission, City Hall, Chicago, Ill.

Philip F. Morgan, professor of sanitary engineering at the University of Iowa, died on Jan. 19, 1961, at Iowa City, Iowa. He was 49 years old. Born in 1911 at Brooklyn, Wis., he received a bachelor's degree in civil engineering from the University of Wisconsin in 1933 and his master's degree in sanitary engineering from the same university in 1935. After working for the Chicago Pump Co., he joined the Mellon Institute for Industrial Research (Kalamazoo, Mich.) in 1945. He went to Iowa University in 1948.

A member of AWWA since 1948, he received the Fuller Award in 1959 and also served the Iowa Section as its chairman. He was also a member of ASCE.

Carl G. Paulsen, formerly chief hydraulic engineer, USGS, died on Jan. 30, 1961, at Caldwell, Idaho, at the age of 73. Born in Chicago, he graduated from the University of Idaho and began his career with the US Bureau of Reclamation in 1911. In 1914 he joined USGS and served there until his retirement in 1957, with the exception of military service during World War I. He was chief hydraulic engineer from 1946 until his retirement.

A member of AWWA since 1947, he was also a member of ASCE (formerly a director) and the American Geophysical Union.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

Water Works Superintendent

Professional engineer to manage municipal water and sewer utility for fast-growing Midwestern capital and university city of 135,000. In addition to its many cultural advantages, Madison is surrounded by large lakes, affording natural recreational opportunities. Depending on experience, beginning salary will be within the range of $10,140 to $12,420 a year. Highest ranking applicants on written examination will be invited to Madison for the oral interviews with travel expenses paid. Apply: Personnel Department, 404 City-County Building, Madison 9, Wisconsin.

Administrator of a small water company with a total of twelve employees. Must have some engineering experience or water works experience, capable of managing the office and supervising the operation of the company. Write: P.O. Box 303, Montebello, California.


"Only The Best"
For ordering dependable and proven pipe line equipment, consult your latest Pollard Catalog #27.
Included in the #27 Catalog, and displayed on this page, are the M-Scope Transistorized Combination Leak Detector and Pipe Locator, Audio-Scope, Geophone Leak Detectors, T-10 Electronic Box Locator, Aqua Valve Box Locator and Magnetic Dipping Needles for locating service boxes.
Hundreds of water departments all over the country are using Pollard "one order" service. You, too, can enjoy the advantages of ordering from the nation's #1 source for dependable pipe line equipment.
NORTH
AUDIO SCOPE
PIPE LINE EQUIPMENT
JOSEPH G. POLLARD CO., INC.
Place your next order with POLLARD
If it's from POLLARD It's the Best in Pipe Line Equipment
NEW HYDE PARK • NEW YORK
Branch Offices: 964 Peoples Gas Building, Chicago, Illinois
333 Candler Building, Atlanta, Georgia
PHONE: PIONEER 6-0842

Index of Advertisers' Products

Coagulant Aids:
Hagan Chemicals & Controls, Inc.
Nalco Chemical Co.
Philadelphia Quartz Co.

Condensers:
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.
Worthington Corp.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Fischer & Porter Co.
Foxboro Co.
General Filter Co.
Simplex Valve & Meter Co.

Copper Sheets:
Anaconda American Brass Co.

Copper Sulfate:
Tennessee Corp.

Corrosion Control:
Calgon Co.
Harco Corp.
Nalco Chemical Co.
Philadelphia Quartz Co.
Southern Pipe Div. of U.S. Industries

Couplings, Flexible:
Dresser Mfg. Div.
Southern Pipe Div. of U.S. Industries

Covers, Vault:
Ford Meter Box Co.
Wachs, E. H., Co.

Diaphragms, Pump:
Dorr-Oliver Inc.

Engineers and Chemists:
(See Professional Services)

Evaporating Equipment:
Ozark-Mahoning Co.

Excavating Equipment:
Charles Machine Works, Inc.
Eimco Corp., The

Feedwater Treatment:
B-I-F Industries, Inc.—Proportioneers
Calgon Co.
Hungerford & Terry, Inc.
Nalco Chemical Co.
Permutit Co.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
General Filter Co.
Johns-Manville Corp.
Multi-Metal Wire Cloth Co., Inc.
Northern Gravel Co.
Permutit Co.
Stuart Corp.

Filters, incl. Feedwater:
B-I-F Industries, Inc.—Proportioneers
Dorr-Oliver Inc.
Eimco Corp., The
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
Chain Belt Co.
Eimco Corp., The
Filtration Equipment Corp.
General Filter Co.
Golden-Anderson Valve Specialty Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Multi-Metal Wire Cloth Co., Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
American Cast Iron Pipe Co.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Morgan Steel Products, Inc.
Southern Pipe Div. of U.S. Industries
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr-Oliver Inc.
Eimco Corp., The
General Filter Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.
General Chemical Div., Allied Chemical Corp.
Olin Mathieson Chemical Corp.
Ozark-Mahoning Co.
Tennessee Corp.

Fluoride Feeders:
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Fischer & Porter Co.
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Fischer & Porter Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Fischer & Porter Co.
Foxboro Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric Analysis Equipment:
Fischer & Porter Co.
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Mueller Co.
Southern Pipe Div. of U.S. Industries

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Photovolt Corp.
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Intake Screens:
Multi-Metal Wire Cloth Co., Inc.

Ion Exchange Materials:
General Filter Co.
Hungerford & Terry, Inc.
Nalco Chemical Co.
Permutit Co.
Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
General Filter Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
James B. Clow & Sons
Dresser Mfg. Div.
Southern Pipe Div. of U.S. Industries
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Aqua Survey & Instrument Co.
Jos. G. Pollard Co., Inc.

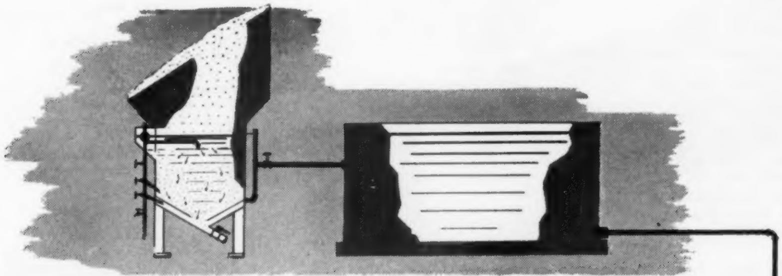
Lime Slakers and Feeders:
B-I-F Industries, Inc.—Omega
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Permutit Co.
Wallace & Tiernan Inc.

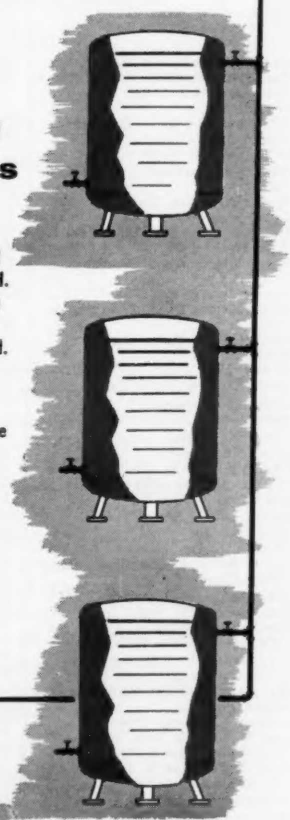
Locators, Pipe & Valve Box:
Aqua Survey & Instrument Co.
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

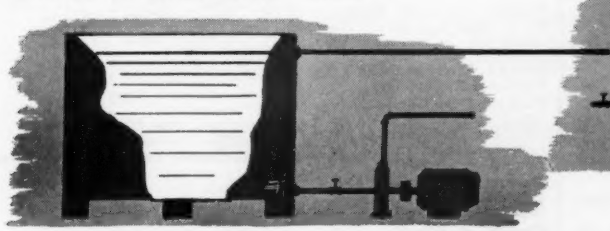
Magnetic Dipping Needles:
Aqua Survey & Instrument Co.
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Rockwell Mfg. Co.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.







Hays Mfg. Co.
Hersey-Sparling Meter Co.
Mueller Co.
Neptune Meter Co.
Rockwell Mfg. Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey-Sparling Meter Co.
Neptune Meter Co.
Rockwell Mfg. Co.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
Hersey-Sparling Meter Co.
Neptune Meter Co.
Rockwell Mfg. Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Fischer & Porter Co.
Simplex Valve & Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Buffalo Meter Co.
Calmet Meter Div., Worthington Corp.
Fischer & Porter Co.
Gamon Meter Div., Worthington Corp.
Hersey-Sparling Meter Co.
Neptune Meter Co.
Rockwell Mfg. Co.
Simplex Valve & Meter Co.

Mixing Equipment:
General Filter Co.
F. B. Leopold Co.

Motors, Electric:
Allis-Chalmers Mfg. Co.
Marathon Electric Mfg. Corp.
Worthington Corp.

Paints:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Pipe, Asbestos-Cement:
Atlas Asbestos Co. Ltd.
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
Anaconda American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
James B. Clow & Sons
Southern Pipe Div. of U.S. Industries
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.
Vulcan Materials Co.

Pipe, Copper:
Anaconda American Brass Co.

Pipe, Plastic:
American Hard Rubber Co.
Keasby & Mattison Co.
Morgan Steel Products, Inc.
Orangeburg Mfg. Co., Div. of The Flintkote Co.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Morgan Steel Products, Inc.
Southern Pipe Div. of U.S. Industries

Pipe Cleaning Services:
Ace Pipe Cleaning, Inc.
Centriline Corp.
National Power Rodding Corp.
National Water Main Cleaning Co.
Robinson Pipe Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
American Hard Rubber Co.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Pipe Linings, Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.
Reilly Tar & Chemical Corp.
Southern Pipe Div. of U.S. Industries

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Pilot Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Wachs, E. H., Co.
Wheeler Mfg. Corp.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators; see Locators, Pipe

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
B-I-F Industries, Inc.—Proportioneers
Fischer & Porter Co.
Precision Chemical Pump Corp.
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Fiese & Firstenberger
Layne & Bowler, Inc.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
Fiese & Firstenberger
Layne & Bowler, Inc.
Peerless Pump Div.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Fischer & Porter Co.
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Bailey Meter Co.
B-I-F Industries, Inc.—Builders
Fischer & Porter Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Eimco Corp., The
General Filter Co.
Infilco Inc.
Permutit Co.

Sodium Aluminate:
Nalco Chemical Co.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.
General Chemical Div., Allied Chemical Corp.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
Jones Chemicals, Inc.
Wallace & Tiernan Inc.

Sodium Silicate:
General Chemical Div., Allied Chemical Corp.
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
General Chemical Div., Allied Chemical Corp.
Tennessee Corp.

Softeners:
Dorr-Oliver Inc.
General Filter Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
International Salt Co., Inc.
Nalco Chemical Co.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Ford Meter Box Co.
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
R. D. Wood Co.

Surface Wash Equipment:
Golden-Anderson Valve Specialty Co.
Permutit Co.

Swimming Pool Sterilization:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Fischer & Porter Co.
Wallace & Tiernan Inc.

Tank Painting and Repair:
Koppers Co., Inc.
National Tank Maintenance Corp.

Tanks, Prestressed Concrete:
Preload Co., Inc.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Proportioneers
General Filter Co.
Industrial Chemical Sales Div.
Permutit Co.
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valve-Operating Units:
B-I-F Industries, Inc.
Filtration Equipment Corp.
Wachs, E. H., Co.
Wheeler, C. H., Mfg. Co.

Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey-Sparling Meter Co.

Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co
M & H Valve & Fittings Co.
Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
B-I-F Industries, Inc.—Builders
Rockwell Mfg. Co.
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
Eimco Corp., The
General Filter Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Reconditioning and Formation Testing:
Halliburton Co.
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

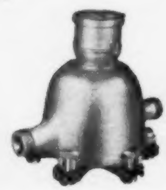
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1959 AWWA Directory.

The Best Disc Meters You Can Buy

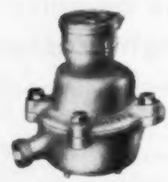
⅝" Arctic Type

¾" Arctic Type

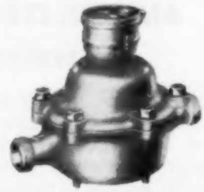


1" Arctic Type

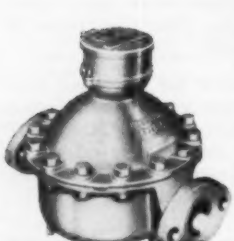
⅝" Tropic Type



¾" Tropic Type



1" Tropic Type



1½" and 2" Disc Type

Millions of Rockwell disc meters are in daily use, giving faithful, accurate service. Their construction has been constantly upgraded to offer you progressively better values. Patented "O-Ring" stuffing box assemblies that won't leak or bind are standard in all sizes. Also standard is stainless steel interior trim to resist corrosion. For your convenience parts are packaged to stack on shelves and labeled to simplify inventory control and re-ordering.

Today, as always, Rockwell offers your best buy in disc meters. For catalog write Rockwell Manufacturing Co., Dept. 163C, Pittsburgh 8, Pa. In Canada: Rockwell Manufacturing Co. of Canada, Ltd., Box 420, Guelph, Ontario.

DISC TYPE WATER METERS

another fine product by

ROCKWELL